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The application claims priority under 35 U.S.C. 119(e) to U.S. Provisional Application Serial No. 60/---,---, which was converted pursuant to 37 C.F.R. § 1.53(b)(2)(ii) from U.S. Patent Application No. 09/466,402, filed on December 17, 1999, the disclosure of which is incorporated herein in its entirety.

Field of the invention

This invention is directed to novel succinate compounds. This invention is also directed to uses of these compounds in various medicinal applications, including treating disorders amenable to treatment by peptidyl deformylase inhibitors. This invention is still further directed to pharmaceutical compounds comprising these compounds and methods of synthesis thereof.

State of the Art

20 Treatment of microbial infection in host organisms requires an effective means to kill the microbe while doing as little harm to the host as possible. Accordingly, agents which target characteristics unique to a pathology-causing microorganism are desirable for treatment. Penicillin is an extremely well known example of such an agent. Penicillin acts by inhibiting biosynthesis of bacterial cell walls. Since
25 mammalian cells do not require cell walls for survival, administration of penicillin to a human infected with bacteria can kill the bacteria without killing human cells.

However, the use of antibiotics and antimicrobials has also resulted in increased resistance to these agents. As bacteria become resistant to older, more widely used antimicrobial agents, new antimicrobials must be developed in order to provide effective treatments for human and non-human animals suffering from microbial infection.

[illegible]

Peptide deformylase is a metallopeptidase found in prokaryotic organisms such as bacteria. Protein synthesis in prokaryotic organisms begins with N-formyl methionine (fMet). After initiation of protein synthesis, the formyl group is removed by the enzyme peptide deformylase (PDF); this activity is essential for maturation of proteins. It has been shown that PDF is required for bacterial growth (Chang et al. *J. Bacteriol.* 171:4071-4072 (1989); Meinnel T, Blanquet S, *J. Bacteriol.* 176(23):7387-90 (1994); Mazel D et al., *EMBO J.* 13(4):914-23 (1994)). Since protein synthesis in eukaryotic organisms does not depend on fMet for initiation, agents that will inhibit PDF are attractive candidates for development of new antimicrobial and antibacterial drugs. Prokaryotic organisms, including disease-causing prokaryotes, are described in Balows, A., H.G. Truper, M. Dworkin, W. Harder, and K.-H. Schleifer (eds.), *The Prokaryotes*, 2nd ed., New York: Springer-Verlag, 1992; and Holt, J.G. (editor-in-chief). *Bergey's Manual of Systematic Bacteriology*, Vols. 1-4, Baltimore: Williams & Wilkins, 1982, 1986, 1989.

PDF is part of the metalloproteinase superfamily. While PDF clearly shares many of the features which characterize metalloproteinases, it differs from other members of the superfamily in several important respects. First, the metal ion in the active enzyme appears to be Fe (II), or possibly another divalent cationic metal, instead of the zinc ion more commonly encountered. Rajagopalan *et al.*, *J. Am. Chem. Soc.*, 119:12418-19 (1997). Second, the divalent ion appears to play an important role, not only in catalysis, but also in the structural integrity of the protein. Third, the third ligand of the divalent ion is a cysteine, rather than a histidine or a glutamate, as in other metalloproteinases and is not located at the C-terminal side of the HEXXH motif but far away along the amino acid sequence and N-terminal to the motif. Finally, the solution structure shows significant differences in the secondary and tertiary structure of PDF compared to other prototypical metalloproteinases *see* Meinnel et al. *J. Mol. Biol.* 262:375-386 (1996). PDF from *E. coli*, *Bacillus stearothermophilus*, and *Thermus thermophilus* have been characterized *see* Meinnel et al., *J Mol Biol* 267:749-761 (1997). The enzyme studied by Meinnel et al. contained a zinc ion as the divalent ion and the structural features summarized above were obtained from zinc-containing proteins. The structure of the protein has also

been determined by NMR (see O'Connell *et al.*, *J. Biomol. NMR* 13(4):311-24 (1999)).

5 Metalloproteinases are critical to many aspects of normal metabolism. The class known as matrix metalloproteinases (MMPs) are involved in tissue remodeling, such as degradation of the extracellular matrix. These enzymes are believed to play a role in normal or beneficial biological events such as the formation of the corpus luteum during pregnancy (see Liu *et al.*, *Endocrinology* 140(11):5330-8 (1999)), wound healing (Yamagiwa *et al.*, *Bone* 25(2):197-203 (1999)), and bone growth in healthy children (Bord *et al.*, *Bone* 23(1):7-12 (1998)). Disorders involving
10 metalloproteinases have been implicated in several diseases such as cancer, arthritis, and autoimmune diseases.

Because of the importance of MMPs in normal physiological processes, it would be preferable to develop agents that inhibit PDF, a metalloproteinase present only in prokaryotes, while avoiding significant inhibition of MMPs. Alternatively,
15 PDF inhibitors which also inhibit MMPs can be of use where the therapeutic benefits of inhibiting PDF outweigh the risk of side effects from MMP inhibition.

A wide variety of compounds have been developed as candidate inhibitors of MMPs and other metalloproteinases, and much effort has also been directed at synthetic methods for these compounds and related compounds. See Izquierdo-
20 Martin *et al.* (1992) *J. Am. Chem. Soc.* 114:325-331; Cushman *et al.* (1981) Chapter 5 "Specific Inhibitors of Zinc Metallopeptidases" in *Topics in Molecular Pharmacology* (Burgen & Roberts, eds.); Mohler *et al.* *Nature* 370:218-220 (1994); Gearing *et al.*, *Nature* 370:555-557 (1994); McGeehan *et al.*, *Nature* 370:558-561 (1994); U.S. Patent Nos. 4,052,511, 4,303,662, 4,311,705, 4,321,383, 4,599,361, 4,804,676,
25 5,128,346, 5,256,657, 5,268,384, 5,447,929, 5,453,423, 5,552,419, 5,614,625, 5,643,908, 5,712,300, and 5,869,518; European patent publications EP 236872, EP 274453, EP 334244, EP 423943, EP 489577, EP 489579, EP 497192, EP 574758; and International PCT Patent Applications Publication Nos. WO 90/05716, WO 90/05719, WO 91/02716, WO 92/13831, WO 92/22523, WO 93/09090,
30 WO 93/09097, WO 93/20047, WO 93/24449, WO 93/24475, WO 94/02446, WO 94/02447, WO 94/21612, WO 94/25434, WO 94/25435, WO 95/33731,

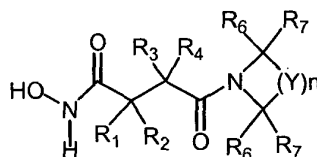
WO 96/25156, WO 96/26918 WO 97/30707, WO 97/49674, WO 98/55449, and WO 99/02510.

Research on inhibitors of PDF is much less extensive than that for inhibitors of MMPs. N-formyl hydroxylamine derivatives are described in International Patent Application WO 99/39704. Peptide aldehyde inhibitors of PDFs are described in Durand *et al.*, *Arch. Biochem. Biophys.*, 367(2):297-302 (1999). The PDF inhibitor (S)-2-O-(H-phosphonoxy)-L-caproyl-L-leucyl-p-nitroanilide is described in Hao *et al.*, *Biochemistry* 38:4712-4719 (1999), and peptidyl H-phosphonate inhibitors of PDF are discussed in Hu *et al.*, *Bioorg. Med. Chem. Lett.* 8:2479-2482 (1998). Formylated peptides and pseudopeptides are described in Meinnel *et al.*, *Biochemistry* 38(14):4288-4295 (1999) as inhibitors of PDF.

In view of the importance of identifying new antibiotics to treat bacteria resistant to existing antibiotics, and the relatively small amount of work that has been carried out on PDF inhibitors, it is desirable to develop novel inhibitors of PDF for evaluation and use as antibacterial and antimicrobial agents. The present invention fulfills this need.

SUMMARY OF THE INVENTION

In one aspect, this invention is directed to a compound of Formula (I):



wherein:

R_1 is hydrogen, halo, -OH, - R_8OR_9 , - R_9 , - OR_9 , -SH, - SR_9 , - NH_2 , - NHR_9 , - NR_9R_{10} , - $NHC(=O)H$, - $NR_9C(=O)H$, - $NHC(=O)R_9$, - $NR_9C(=O)R_{10}$, - $NHC(=O)NH_2$, - $NR_9C(=O)NH_2$, - $NHC(=O)NHR_9$, - $NHC(=O)NR_9R_{10}$, - $NR_9C(=O)NR_9R_{10}$, - $NHC(=O)OR_9$, - $NR_9C(=O)OR_{10}$, - $NHS(=O)_2R_9$, - $NR_9S(=O)_2R_{10}$, - $NHS(=O)_2OR_9$, or - $NR_9S(=O)_2OR_{10}$ where R_8 is selected from the group consisting of - C_1 - C_{12} alkylene, substituted alkylene, or heteroalkylene, - C_1 - C_{12} alkenylene, substituted alkenylene, or heteroalkenylene, - C_1 - C_{12} alkynylene, substituted alkynylene, or heteroalkynylene,

and $-(C_1-C_8 \text{ alkylene or substituted alkylene})_{n1}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n2}$ where $n1$ and $n2$ are independently 0 or 1; and R_9 , R_{9a} and R_{10} are independently selected from the group consisting of $-C_1-C_{12}$ alkyl, substituted alkyl, or heteroalkyl, $-C_1-C_{12}$ alkenyl, substituted alkenyl, or heteroalkenyl, $-C_1-C_{12}$ alkynyl, substituted alkynyl, or heteroalkynyl, and $-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n3}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n4}$ where $n3$ and $n4$ are independently 0 or 1;

R_2 is independently hydrogen or $-R_9$ wherein R_9 is as defined above;

R_3 is hydrogen, halo, $-R_{11}$, $-OH$, $-OR_{11}$, $-R_{12}OR_{11}$, $-SH$, $-SR_{11}$, $-NH_2$, $-NHR_{11}$, $-NR_{11}R_{13}$, $-NHC(=O)H$, $-NR_{11}C(=O)H$, $-NHC(=O)R_{11}$, $-NR_{11}C(=O)R_{13}$, $-NHC(=O)NH_2$, $-NR_{11}C(=O)NH_2$, $-NHC(=O)NHR_{11}$, $-NHC(=O)NR_{11}R_{13}$, $-NR_{11}C(=O)NR_{11a}R_{13}$, $-NHC(=O)OR_{11}$, $-NR_{11}C(=O)OR_{13}$, $-NHS(=O)_2R_{13}$, $-NR_{11}S(=O)_2R_{13}$, $-NHS(=O)_2OR_{11}$, or $-NR_{11}S(=O)_2OR_{13}$, where R_{12} is selected from the group consisting of $-C_1-C_{12}$ alkylene, substituted alkylene, or heteroalkylene, $-C_1-C_{12}$ alkenylene, substituted alkenylene, or heteroalkenylene, $-C_1-C_{12}$ alkynylene, substituted alkynylene, or heteroalkynylene, and $-(C_1-C_8 \text{ alkylene or substituted alkylene})_{n5}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n6}$ where $n5$ and $n6$ are independently 0 or 1; and R_{11} , R_{11a} and R_{13} are independently selected from the group consisting of $-C_1-C_{12}$ alkyl, substituted alkyl, or heteroalkyl, $-C_1-C_{12}$ alkenyl, substituted alkenyl, or heteroalkenyl, $-C_1-C_{12}$ alkynyl, substituted alkynyl, or heteroalkynyl, and $-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n7}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n8}$ where $n7$ and $n8$ are independently 0 or 1;

R_4 is hydrogen or $-R_{11}$ where $-R_{11}$ is as defined above;

n is an integer from 1 to 5;

zero or one Y is selected from the group consisting of $-O-$, $-NR_{11}-$ where R_{11} is as defined above, and $-S-$, and all remaining Y are $-CR_6R_7-$ where R_6 and R_7 are each independently selected from the group consisting of hydrogen, $-R_{14}$, $-OH$, $-OR_{14}$, $-SH$, $-SR_{14}$, $-NH_2$, $-NHR_{14}$, $-NR_{14}R_{15}$, $-C(=O)H$, $-C(=O)R_{14}$, $-C(=O)NH_2$, $-C(=O)NHR_{14}$, $-C(=O)NR_{14}R_{15}$, $-C(=O)OH$, $-C(=O)OR_{14}$, $-C(=O)SH$, $-C(=O)SR_{14}$, $-C(=O)CH_3$, $-C(=O)CH_2R_{14}$, $-C(=O)CHR_{14}R_{15}$, $-C(=O)CR_{14}R_{15}R_{16}$, $-C(=O)OCH_3$, $-C(=O)OCH_2R_{14}$, $-C(=O)OCHR_{14}R_{15}$, $-C(=O)OCR_{14}R_{15}R_{16}$, $-S(=O)_2NH_2$,

-S(=O)₂NHR₁₄, -S(=O)₂NR₁₄R₁₅, -NHC(=O)H, -N(R₁₄)C(=O)H, -NHC(=O)R₁₅,
 -N(R₁₄)C(=O)R₁₅, -NHC(=O)OR₁₄, -NHS(=O)₂H, -N(R₁₄)S(=O)₂H, -NHS(=O)₂OR₁₅,
 -N(R₁₄)S(=O)₂OR₁₅, -N(H)S(=O)₂R₁₅, -N(R₁₄)S(=O)₂R₁₅ and where two vicinal R₆ or
 5 heteroalkyl, aryl or heteroaryl group where R₁₄, R₁₅ and R₁₆ are each independently
 selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl,
 -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted
 alkynyl, or heteroalkynyl, alkoxy, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂
 10 arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are
 independently 0 or 1; or when R₁₄ and R₁₅ are attached to a nitrogen atom they can
 combine to form a substituted or unsubstituted -C₄-C₁₀ cyclic alkyl, cyclic
 heteroalkyl, aryl or heteroaryl group; or
 a pharmaceutically acceptable salt thereof.

Preferably the compound of Formula (I) inhibits peptidyl deformylase at an
 15 IC₅₀ of less than or equal to about 100 nm, preferably of less than or equal to 10 nm,
 more preferably of less than or equal to 1 nm.

Preferably the compound of Formula (I) displays a selectivity for peptidyl
 deformylase over at least one metalloproteinase selected from the group consisting of
 ACE and Matrilysin of greater than or equal to about 10 times, more preferably of
 20 greater than or equal to about 100 times, still more preferably of greater than or equal
 to about 1000 times.

In a second aspect, this invention is directed to pharmaceutical compositions
 comprising a therapeutically effective amount of a compound of Formula (I) or a
 pharmaceutically acceptable salt thereof and a pharmaceutically acceptable excipient.

25 In a third aspect, this invention is directed to a method of treatment of a
 disease in a mammal treatable by administration of a peptidyl deformylase inhibitor
 which method comprises administration of a therapeutically effective amount of a
 pharmaceutical composition comprising a therapeutically effective amount of a
 compound of Formula (I) or a pharmaceutically acceptable salt thereof and a
 30 pharmaceutically acceptable excipient either alone or in combination with other
 pharmacologically active agents. In particular, the compounds of this invention are
 useful in treating microbial diseases. The microbial infection can be due to bacteria,

other prokaryotes, or other organisms, including parasites, dependent on peptide deformylase for growth or survival.

In a fourth aspect, this invention is directed to the use of a compound of Formula (I) or a pharmaceutically acceptable salts thereof in the preparation of a medicament for use in the treatment of diseases mediated by peptidyl deformylase enzyme.

In a fifth aspect, this invention is directed to a method for identifying compounds useful in treating microbial infections, comprising performing an assay to identify compounds which meet the criterion of either i) an IC_{50} for peptide deformylase of less than or equal to about 1 μM , or ii) an MIC for a disease-causing pathogen of less than or equal to about 32 $\mu g/ml$; performing an assay to identify compounds which meet the criterion of iii) displaying a selectivity for peptide deformylase over at least one metalloproteinase selected from the group consisting of Angiotensin Converting Enzyme (ACE) and Matrilysin of greater than or equal to about 10 times; and selecting compounds which meet either both criteria i) and iii), or both criteria ii) and iii). More preferably, the compounds so identified meet the criterion of either i) an IC_{50} for peptide deformylase of less than or equal to about 100 nM, or ii) an MIC for a disease-causing pathogen of less than or equal to about 10 $\mu g/ml$.

DETAILED DESCRIPTION OF THE INVENTION

Unless otherwise stated, the following terms as used in the specification have the following meaning.

The term "alkyl" refers to saturated aliphatic groups including straight-chain, branched-chain, cyclic groups, and combinations thereof, having the number of carbon atoms specified, or if no number is specified, having 1 to 12 carbon atoms. Examples of alkyl groups include, but are not limited to, groups such as methyl, ethyl, n-propyl, isopropyl, n-butyl, isobutyl, sec-butyl, t-butyl, n-pentyl, neopentyl, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, cyclobutylmethyl, cyclobutylethyl, cyclopentylmethyl, cyclopentylethyl, and adamantyl. Cyclic alkyl groups can consist of one ring, including, but not limited to, groups such as cycloheptyl, or multiple fused rings, including, but not limited to, groups such as adamantyl or norbornyl.

The term "alkylene" means a saturated divalent aliphatic groups including straight-chain, branched-chain, cyclic groups, and combinations thereof, having the number of carbon atoms specified, or if no number is specified, having 1 to 12 carbon atoms, e.g., methylene, ethylene, 2,2-dimethylethylene, propylene, 2-methyl-
5 propylene, butylene, pentylene, cyclopentylmethylene, and the like.

The term "substituted alkyl" means an alkyl group as defined above that is substituted with one or more substituents, preferably one to three substituents selected from the group consisting of halogen (fluoro, chloro, bromo, and iodo, preferably fluoro, chloro, or bromo), alkoxy, acyloxy, amino, mono or dialkylamino, hydroxyl,
10 mercapto, carboxy, benzyloxy, phenyl, benzyl, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide, or a functionality that can be suitably blocked, if necessary for purposes of the invention, with a protecting group. The phenyl group may optionally be substituted with one to three substituents selected from the group consisting of halogen (fluoro, chloro, bromo, and iodo, preferably
15 fluoro, chloro, or bromo), alkoxy, acyloxy, amino, mono or dialkylamino, hydroxyl, mercapto, carboxy, benzyloxy, benzyl, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide. Examples of substituted alkyl groups include, but are not limited to, -CF₃, -CF₂-CF₃, hydroxymethyl, 1- or 2-hydroxyethyl, methoxymethyl, 1- or 2-ethoxyethyl, carboxymethyl, 1- or 2- carboxyethyl, methoxycarbonylmethyl,
20 1- or 2-methoxycarbonyl ethyl, benzyl, and the like.

The term "substituted alkylene" means an alkylene group as defined above that is substituted with one or more substituents, preferably one to three substituents, selected from the group consisting of halogen (fluoro, chloro, bromo, and iodo, preferably fluoro, chloro, or bromo), alkoxy, acyloxy, amino, mono or dialkylamino,
25 hydroxyl, mercapto, carboxy, benzyloxy, phenyl, benzyl, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide, or a functionality that can be suitably blocked, if necessary for purposes of the invention, with a protecting group. The phenyl group may optionally be substituted with one to three substituents selected from the group consisting of halogen (fluoro, chloro, bromo, and iodo, preferably
30 fluoro, chloro, or bromo), alkoxy, acyloxy, amino, mono or dialkylamino, hydroxyl, mercapto, carboxy, benzyloxy, benzyl, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide. Examples of substituted alkyl groups include, but are

not limited to, -CF₂-, -CF₂-CF₂-, hydroxymethylene, 1- or 2-hydroxyethylene, methoxymethylene, 1- or 2-ethoxyethylene, carboxymethylene, 1- or 2-carboxyethylene, and the like.

The term "alkenyl" refers to unsaturated aliphatic groups including straight-chain, branched-chain, cyclic groups, and combinations thereof, having the number of carbon atoms specified, or if no number is specified, having 1 to 12 carbon atoms, which contain at least one double bond (-C=C-). Examples of alkenyl groups include, but are not limited to, allyl vinyl, -CH₂-CH=CH-CH₃, -CH₂-CH₂-cyclopentenyl and -CH₂-CH₂-cyclohexenyl where the ethyl group can be attached to the cyclopentenyl, cyclohexenyl moiety at any available carbon valence.

The term "alkenylene" refers to unsaturated divalent aliphatic groups including straight-chain, branched-chain, cyclic groups, and combinations thereof, having the number of carbon atoms specified, or if no number is specified, having 1 to 12 carbon atoms, which contain at least one double bond (-C=C-). Examples of alkenylene groups include, but are not limited to, -CH=CH-, -CH₂-CH=CH-CH₂-, -CH₂-CH(cyclopentenyl)- and the like.

The term "alkynyl" refers to unsaturated aliphatic groups including straight-chain, branched-chain, cyclic groups, and combinations thereof, having the number of carbon atoms specified, or if no number is specified, having 1 to 12 carbon atoms, which contain at least one triple bond (-C≡C-). Examples of alkynyl groups include, but are not limited to, acetylene, 2-butyne, and the like.

The term "alkynylene" refers to unsaturated divalent aliphatic groups including straight-chain, branched-chain, cyclic groups, and combinations thereof, having the number of carbon atoms specified, or if no number is specified, having 1 to 12 carbon atoms, which contain at least one triple bond (-C≡C-). Examples of alkynylene groups include, but are not limited to, -C≡C-, -C≡C-CH₂-, and the like.

The term "substituted alkenyl" or "substituted alkynyl," refers to the alkenyl and alkynyl groups as defined above that are substituted with one or more substituents, selected from the group consisting of halogen, alkoxy, acyloxy, amino, hydroxyl, mercapto, carboxy, benzyloxy, phenyl, benzyl, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide, or a functionality that can be suitably

blocked, if necessary for purposes of the invention, with a protecting group.

Examples of substituted alkenyl and alkynyl groups include, but are not limited to, -CH=CF₂, hydroxyethenyl, methoxypropenyl, hydroxypropynyl, and the like.

5 The term "substituted alkenylene" or "substituted alkynylene," refers to the alkenylene and alkynylene groups as defined above that are substituted with one or more substituents, selected from the group consisting of halogen, alkoxy, acyloxy, amino, hydroxyl, mercapto, carboxy, benzyloxy, phenyl, benzyl, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide, or a functionality that can be suitably blocked, if necessary for purposes of the invention, with a protecting
10 group.

The term "aryl" or "Ar" refers to an aromatic carbocyclic group of 6 to 14 carbon atoms having a single ring (including, but not limited to, groups such as phenyl) or multiple condensed rings (including, but not limited to, groups such as naphthyl or anthryl), and includes both unsubstituted and substituted aryl groups.
15 Substituted aryl is an aryl group that is substituted with one or more substituents, preferably one to three substituents, selected from the group consisting of alkyl, alkenyl, alkynyl, halogen, alkoxy, acyloxy, amino, mono or dialkylamino, hydroxyl, mercapto, carboxy, benzyloxy, phenyl, aryloxy, benzyl, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide, or a functionality that can be suitably
20 blocked, if necessary for purposes of the invention, with a protecting group.

Representative examples include, but are not limited to, naphthyl, phenyl, chlorophenyl, iodophenyl, methoxyphenyl, carboxyphenyl, and the like.

The term "arylene" refers to the diradical derived from aryl (including substituted aryl) as defined above and is exemplified by 1,2-phenylene, 1,3-
25 phenylene, 1,4-phenylene, 1,2-naphthylene and the like.

The term "amino" refers to the group -NH₂.

The term "thioalkoxy" means a radical -SR where R is an alkyl as defined above e.g., methylthio, ethylthio, propylthio, butylthio, and the like.

The term "mono and "dialkylamino" means a radical -NHR and -NRR' respectively where R and R' independently represent an alkyl group as defined herein.
30 Representative examples include, but are not limited to dimethylamino, methylethylamino, di(1-methylethyl)amino, (cyclohexyl)(methyl)amino,

(cyclohexyl)(ethyl)amino, (cyclohexyl)(propyl)amino, (cyclohexylmethyl)(methyl)-amino, (cyclohexylmethyl)(ethyl)amino, and the like.

The term "acyloxy" means a radical $-OC(O)R$, where R is hydrogen, alkyl, aryl, heteroaryl or substituted alkyl wherein alkyl, aryl, heteroaryl, and substituted alkyl are as defined herein. Representative examples include, but are not limited to
5 formyl, acetyloxy, cyclohexylcarbonyloxy, cyclohexylmethylcarbonyloxy, benzoyloxy, benzylcarbonyloxy, and the like.

The term "heteroalkyl," "heteroalkenyl," and "heteroalkynyl" refers to alkyl, alkenyl, and alkynyl groups respectively as defined above, that contain the number of
10 carbon atoms specified (or if no number is specified, having 1 to 12 carbon atoms) which contain one or more heteroatoms, preferably one to three heteroatoms, as part of the main, branched, or cyclic chains in the group. Heteroatoms are independently selected from the group consisting of $-NR-$, $-NRR$, (where each R is hydrogen or alkyl), $-S-$, $-O-$, $-SR$ (R is hydrogen or alkyl), $-OR$ (R is hydrogen or alkyl), and P;
15 preferably $-NR$ where R is hydrogen or alkyl and/or O. Heteroalkyl, heteroalkenyl, and heteroalkynyl groups may be attached to the remainder of the molecule either at a heteroatom (if a valence is available) or at a carbon atom. Examples of heteroalkyl groups include, but are not limited to, groups such as $-O-CH_3$, $-CH_2-O-CH_3$, $-CH_2-CH_2-O-CH_3$, $-S-CH_2-CH_2-CH_3$, $-CH_2-CH(CH_3)-S-CH_3$,
20 $-CH_2-CH_2-NH-CH_2-CH_3$, 1-ethyl-6-propylpiperidino, 2-ethylthiophenyl, piperazino, pyrrolidino, piperidino, morpholino, and the like. Examples of heteroalkenyl groups include, but are not limited to, groups such as $-CH=CH-NH-CH(CH_3)-CH_3$, and the like.

The term "carboxaldehyde" means $-CHO$.

25 The term "carboalkoxy" means $-C(O)OR$ where R is alkyl as defined above and include groups such as methoxycarbonyl, ethoxycarbonyl, and the like.

The term "carboxamide" means $-C(O)NHR$ or $-C(O)NRR'$ where R and R' are independently hydrogen or alkyl as defined above. Representative examples include groups such as aminocarbonyl, methylaminocarbonyl,
30 dimethylaminocarbonyl, and the like.

The term "heteroaryl" or "HetAr" refers to an aromatic carbocyclic group of 3 to 9 ring atoms forming a single ring and having at least one hetero atom, preferably

one to three heteroatoms including, but not limited to, heteroatoms such as N, O, P, or S, within the ring. Representative examples include, but are not limited to single ring such as imidazolyl, pyrazolyl, pyrazinyl, pyridazinyl, pyrimidinyl, pyrrolyl, pyridyl, thiophene, and the like, or multiple condensed rings such as indolyl, quinoline, quinazoline, benzimidazolyl, indoliziny, benzothienyl, and the like.

The heteroalkyl, heteroalkenyl, heteroalkynyl and heteroaryl groups can be unsubstituted or substituted with one or more substituents, preferably one to three substituents, selected from the group consisting of alkyl, alkenyl, alkynyl, benzyl, halogen, alkoxy, acyloxy, amino, mono or dialkylamino, hydroxyl, mercapto, carboxy, benzyloxy, phenyl, aryloxy, cyano, nitro, thioalkoxy, carboxaldehyde, carboalkoxy and carboxamide, or a functionality that can be suitably blocked, if necessary for purposes of the invention, with a protecting group. Examples of such substituted heteroalkyl groups include, but are not limited to, piperazine, pyrrolidine, morpholine, or piperidine, substituted at a nitrogen or carbon by a phenyl or benzyl group, and attached to the remainder of the molecule by any available valence on a carbon or nitrogen, -NH-SO₂-phenyl, -NH-(C=O)O-alkyl, -NH-(C=O)O-alkyl-aryl, and the like. The heteroatom(s) as well as the carbon atoms of the group can be substituted. The heteroatom(s) can also be in oxidized form.

The term "heteroarylene" refers to the diradical group derived from heteroaryl (including substituted heteroaryl), as defined above, and is exemplified by the groups 2,6-pyridylene, 2,4-pyridinylene, 1,2-quinolinyne, 1,8-quinolinyne, 1,4-benzofuranylene, 2,5-pyridinyne, 2,5-indolenyl, and the like.

The term "heteroalkylene", "heteroalkenylene", and "heteroalkynylene" refers to the diradical group derived from heteroalkyl, heteroalkenyl, and heteroalkynyl (including substituted heteroalkyl, heteroalkenyl, and heteroalkynyl), as defined above.

The term "alkylaryl" refers to an alkyl group having the number of carbon atoms designated, appended to one, two, or three aryl groups.

The term "alkoxy" as used herein refers to an alkyl, alkenyl, or alkynyl linked to an oxygen atom and having the number of carbon atoms specified, or if no number is specified, having 1 to 12 carbon atoms. Examples of alkoxy groups include, but are not limited to, groups such as methoxy, ethoxy, *tert*-butoxy, and allyloxy.

like) and heteroarylene groups have 3 to 12 carbons atoms and additionally contain one to three heteroatoms including, but not limited to, heteroatoms such as N, O, P, or S, within the ring (e.g., 2,6-pyridylene, 2,4-pyridinylene, 1,2-quinolinylene, 1,8-quinolinylene, 1,4-benzofuranylene, 2,5-pyridylene, 2,5-indolenyl, and the like) in accordance with the definition of the heteroarylene above. Additionally, it will be recognized by a person skilled in the art that when “-(C₁-C₈ alkylene or substituted alkylene)- ” and “-(C₁-C₈ alkyl or substituted alkyl)- ” are a covalent bond then - (C₃-C₁₂ arylene or heteroarylene)- is an aryl or heteroaryl group as defined above.

“Protecting group” refers to a chemical group that exhibits the following characteristics: 1) reacts selectively with the desired functionality in good yield to give a protected substrate that is stable to the projected reactions for which protection is desired; 2) is selectively removable from the protected substrate to yield the desired functionality; and 3) is removable in good yield by reagents compatible with the other functional group(s) present or generated in such projected reactions. Examples of suitable protecting groups can be found in Greene et al. (1991) *Protective Groups in Organic Synthesis*, 2nd Ed. (John Wiley & Sons, Inc., New York). Preferred amino protecting groups include, but are not limited to, benzyloxycarbonyl (CBz), t-butyl-oxycarbonyl (Boc), t-butyltrimethylsilyl (TBDMS), 9-fluorenylmethyl-oxycarbonyl (Fmoc), or suitable photolabile protecting groups such as 6-nitroveratryloxy carbonyl (Nvoc), nitropiperonyl, pyrenylmethoxycarbonyl, nitrobenzyl, dimethyl dimethoxybenzyl, 5-bromo-7-nitroindoliny, and the like. Preferred hydroxyl protecting groups include Fmoc, TBDMS, photolabile protecting groups (such as nitroveratryl oxymethyl ether (Nvom)), Mom (methoxy methyl ether), and Mem (methoxy ethoxy methyl ether). Particularly preferred protecting groups include NPEOC (4-nitrophenethyloxycarbonyl) and NPEOM (4-nitrophenethyloxy-methyloxycarbonyl).

“Inhibitor” refers to a compound that interferes with the interaction between a target and its respective substrate(s) or endogenous ligand(s). Target molecules include, but are not limited to, enzymes and receptors. Enzyme inhibitors have been extensively studied from kinetic and mechanistic standpoints; *see, e.g.*, Fersht, A., *Enzyme Structure and Mechanism*, 2nd Ed., New York, W.H. Freeman, 1985. A

useful measure of the effectiveness of a compound at inhibiting enzyme catalysis is the IC_{50} of that compound. The IC_{50} of a compound can be determined by the equation $y = y_0 / (1 + [In] / IC_{50})$

where y is the measured reaction velocity, y_0 is the reaction velocity in the absence of inhibitor, and $[In]$ is the inhibitor concentration. Solving this equation at the inhibitor concentration $[In]$ when $y = y_0 / 2$ yields IC_{50} of the inhibitor for the enzyme under study. Useful inhibitors have an IC_{50} equal to or less than about 10 μM , preferably equal to or less than about 1 μM . More preferably, the inhibitor has an IC_{50} equal to or less than about 100 nM, still more preferably equal to or less than about 10 nM, even more preferably equal to or less than about 1 nM. Most preferably, inhibitors have an IC_{50} equal to or less than about 100 pM, or equal to or less than about 10 pM.

A selective inhibitor refers to an inhibitor that will inhibit the activity of one macromolecule, typically an enzyme, while exhibiting little or no inhibitory effect on another macromolecule, typically another enzyme. The compounds of the invention are particularly useful in that they display selective inhibition of peptidyl deformylase while exhibiting much lower inhibitory activity towards metalloproteinases such as matrilysin. The selectivity of an enzyme inhibitor can be indicated by dividing the IC_{50} of the compound for the enzyme which is not intended to be inhibited, by the IC_{50} of the compound for the enzyme which is intended to be inhibited. Thus, if a compound has an IC_{50} for matrilysin of 1 μM , and an IC_{50} for peptidyl deformylase of 0.01 μM , the compound displays a 100-fold (or 100 times) selectivity for peptidyl deformylase over matrilysin, or alternatively is said to be 100 times more selective for peptidyl deformylase compared to matrilysin. Useful compounds display a selectivity of greater than or equal to about 10 times, preferably greater than or equal to about 100 times, more preferably greater than or equal to about 1000 times, still more preferably greater than or equal to about 10,000, for peptidyl deformylase over one or more other metalloproteinases, for example for peptidyl deformylase over matrilysin.

The compounds of the invention are intended for use in eukaryotic animals. Preferably, the animal is a vertebrate; more preferably, the animal is a mammal; most preferably, the animal is a human.

By "hydroxamic acid derivative," "hydroxamic acid derivative compound," "hydroxamic acid compound," "hydroxamate derivative," "hydroxamate derivative compound," or "hydroxamate compound" is meant any compound containing the functional group $\text{HN}(\text{OH})\text{-C}(=\text{O})\text{-}$.

5 Compounds that have the same molecular formula but differ in the nature or sequence of bonding of their atoms or the arrangement of their atoms in space are termed "isomers". Isomers that differ in the arrangement of their atoms in space are termed "stereoisomers". Stereoisomers that are not mirror images of one another are termed "diastereomers" and those that are non-superimposable mirror images of each
10 other are termed "enantiomers". When a compound has an asymmetric center, for example, it is bonded to four different groups, a pair of enantiomers is possible. An enantiomer can be characterized by the absolute configuration of its asymmetric center and is described by the *R*- and *S*-sequencing rules of Cahn and Prelog, or by the manner in which the molecule rotates the plane of polarized light and designated as
15 dextrorotatory or levorotatory (i.e., as (+) or (-)-isomers respectively). A chiral compound can exist as either individual enantiomer or as a mixture thereof. A mixture containing equal proportions of the enantiomers is called a "racemic mixture".

 The compounds of this invention may possess one or more asymmetric
20 centers; such compounds can therefore be produced as individual (*R*)- or (*S*)-stereoisomers or as mixtures thereof. For example, if the R_6 substituent in a compound of Formula (I) is 2-hydroxyethyl, then the carbon to which the hydroxy group is attached is an asymmetric center and therefore the compound of Formula (I) can exist as an (*R*)- or (*S*)-stereoisomer. Unless indicated otherwise, the description
25 or naming of a particular compound in the specification and claims is intended to include both individual enantiomers and mixtures, racemic or otherwise, thereof. The methods for the determination of stereochemistry and the separation of stereoisomers are well-known in the art (*see* discussion in Chapter 4 of "Advanced Organic Chemistry", 4th edition J. March, John Wiley and Sons, New York, 1992).

30 A "pharmaceutically acceptable excipient" means an excipient that is useful in preparing a pharmaceutical composition that is generally safe, non-toxic and neither biologically nor otherwise undesirable, and includes an excipient that is acceptable for

veterinary use as well as human pharmaceutical use. A "pharmaceutically acceptable excipient" as used in the specification and claims includes both one and more than one such excipient.

5 A "pharmaceutically acceptable salt" of a compound means a salt that is pharmaceutically acceptable and that possesses the desired pharmacological activity of the parent compound. Such salts include:

(1) acid addition salts, formed with inorganic acids such as hydrochloric acid, hydrobromic acid, sulfuric acid, nitric acid, phosphoric acid, and the like; or formed with organic acids such as acetic acid, propionic acid, hexanoic acid, cyclopentanepropionic acid, glycolic acid, pyruvic acid, lactic acid, malonic acid, succinic acid, malic acid, maleic acid, fumaric acid, tartaric acid, citric acid, benzoic acid, 3-(4-hydroxybenzoyl)benzoic acid, cinnamic acid, mandelic acid, methanesulfonic acid, ethanesulfonic acid, 1,2-ethane-disulfonic acid, 2-hydroxyethanesulfonic acid, benzenesulfonic acid, 4-chlorobenzenesulfonic acid, 2-naphthalenesulfonic acid, 4-toluenesulfonic acid, camphorsulfonic acid, 3-phenylpropionic acid, trimethylacetic acid, tertiary butylacetic acid, lauryl sulfuric acid, gluconic acid, glutamic acid, hydroxynaphthoic acid, salicylic acid, stearic acid, muconic acid, and the like; or

10
15

(2) salts formed when an acidic proton present in the parent compound either is replaced by a metal ion, e.g., an alkali metal ion, an alkaline earth ion, or an aluminum ion; or coordinates with an organic base such as ethanolamine, diethanolamine, triethanolamine, tromethamine, N-methylglucamine, and the like.

20

A compound of Formula (I) may act as a pro-drug. Prodrug means any compound which releases an active parent drug according to Formula (I) *in vivo* when such prodrug is administered to a mammalian subject. Prodrugs of a compound of Formula (I) are prepared by modifying functional groups present in the compound of Formula (I) in such a way that the modifications may be cleaved *in vivo* to release the parent compound. Prodrugs include compounds of Formula (I) wherein a hydroxy, amino, or sulfhydryl group in compound (I) is bonded to any group that may be cleaved *in vivo* to regenerate the free hydroxyl, amino, or sulfhydryl group, respectively. Examples of prodrugs include, but are not limited to esters (e.g., acetate,

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formate, and benzoate derivatives), carbamates (e.g., N,N-dimethylamino-carbonyl) of hydroxy functional groups in compounds of Formula (I), and the like.

"Treating" or "treatment" of a disease includes:

- (1) preventing the disease, i.e. causing the clinical symptoms of the disease not to develop in a mammal that may be exposed to or predisposed to the disease but does not yet experience or display symptoms of the disease,
- (2) inhibiting the disease, i.e., arresting or reducing the development of the disease or its clinical symptoms, or
- (3) relieving the disease, i.e., causing regression of the disease or its clinical symptoms.

A "therapeutically effective amount" means the amount of a compound that, when administered to a mammal for treating a disease, is sufficient to effect such treatment for the disease. The "therapeutically effective amount" will vary depending on the compound, the disease and its severity and the age, weight, etc., of the mammal to be treated.

PREFERRED EMBODIMENTS

While the broadest definition of this invention is set forth in the Summary of the Invention, certain compounds of Formula (I) are preferred. For example,

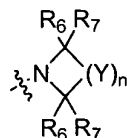
(A) (i) A preferred group of compounds is that wherein R_1 is hydrogen or hydroxy, preferably hydroxy. The stereochemistry at the carbon carrying the R_1 group is (*R*) or (*S*).

(ii) Another preferred group of compounds is that wherein R_1 is halo; preferably chloro or fluoro; more preferably fluoro. The stereochemistry at the carbon carrying the R_1 group is (*R*) or (*S*), preferably (*S*) when R_1 is fluoro.

Within the above preferred groups, a more preferred group of compounds is that wherein R_2 and R_4 are hydrogen.

(iii) Yet another preferred group of compounds is that wherein R_3 is hydrogen or R_{11} where R_{11} is $-C_1-C_{12}$ alkyl or $-(C_1-C_8 \text{ alkylene})_n-(C_3-C_{12} \text{ aryl or heteroaryl})$, preferably methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *iso*-butyl, *tert*-butyl, *n*-pentyl, *iso*-pentyl, *neo*-pentyl, *n*-hexyl, 2-, 3-, 4-, or 5-methylpentyl, 4,4-dimethylbutyl,

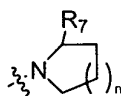
benzyl, 3-phenylpropyl, 2-phenylethyl, or 4-phenylbutyl, more preferably *n*-butyl.
The stereochemistry at the carbon carrying the R₃ group is (*R*) or (*S*), preferably (*R*).



(iv) Yet another preferred group of compounds is that wherein the

5

group is a group of formula:



10 wherein:

n is 1 or 2, preferably 1; and

R₇ is:

(a) -C(=O)NR₁₄R₁₅ where R₁₄ and R₁₅ are independently selected from the group
consisting of hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂)
15 alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl,
or heteroalkynyl, alkoxy, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or
heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are
independently 0 or 1; or R₁₄ and R₁₅ combine to form a substituted or unsubstituted -
20 (C₄-C₁₀)cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group.

20 Preferably, R₇ is -C(=O)NR₁₄R₁₅ where R₁₄ and R₁₅ are each independently
hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, heteroaryl or R₁₄ and R₁₅, when attached to
the same carbon, combine to form a cyclic heteroalkyl, aryl or heteroaryl group.

More preferably, R₇ is -C(=O)NHR₁₅ where R₁₅ is H or -(C₁-C₁₂) alkyl, aryl,
or heteroaryl or -C(=O)NR₁₄R₁₅ where R₁₄ and R₁₅ form a substituted or unsubstituted
25 -(C₄-C₁₀)cyclic heteroalkyl.

Even more preferably R₇ is *n*-butylaminocarbonyl, *tert*-butylaminocarbonyl, benzylaminocarbonyl, 1,1-dimethylpropylaminocarbonyl, 2-(cyclohexen-1-yl)-ethylaminocarbonyl, indan-5-ylaminocarbonyl, 4,5-dimethylthiazol-2-ylaminocarbonyl, 4-phenoxyphenylaminocarbonyl, cyclopropylmethyl-aminocarbonyl, pyridin-2-ylaminocarbonyl, pyridin-3-ylaminocarbonyl, pyridin-4-ylmethylaminocarbonyl, morpholin-4-ylcarbonyl, 3,4-methylenedioxy-phenylaminocarbonyl, quinolin-3-ylaminocarbonyl, methylaminocarbonyl, 4-biphenylaminocarbonyl, 3-phenoxyphenylaminocarbonyl, 3,4-dichlorophenyl-aminocarbonyl, 4-*tert*-butylphenylaminocarbonyl, 4-*tert*-butylaminocarbonyl, indan-2-ylaminocarbonyl, 2,2-dimethylpropylaminocarbonyl, 4-phenylthiazol-2-ylaminocarbonyl, 5-phenylthiadiazol-2-ylaminocarbonyl, 5-ethylthiadiazol-3-ylaminocarbonyl, thiadiazol-2-ylaminocarbonyl, 3-trifluoromethoxyphenyl-aminocarbonyl, 2,5-dimethylphenylaminocarbonyl, 2,5-dimethoxyphenylamino-carbonyl, 3,4-dichlorophenylaminocarbonyl, benzthiazol-2-ylaminocarbonyl, 3-phenoxyphenylaminocarbonyl, 2-hydroxybutylaminocarbonyl, 4-hydroxybutyl-aminocarbonyl, 1,4-benzodioxan-6-ylaminocarbonyl, isoquinolin-6-ylaminocarbonyl, methylaminocarbonyl, thiazol-2-ylaminocarbonyl, 4-methylthiazol-2-yl-aminocarbonyl, 3-methylbutyl-aminocarbonyl, *n*-pentylaminocarbonyl, cyclohexylaminocarbonyl, 5-methylthiazol-2-ylaminocarbonyl, 4-methylthiazol-2-yl-aminocarbonyl, 2,4-dimethoxyphenyl-aminocarbonyl, 3,4-methylenedioxyphen-5-yl-methylaminocarbonyl, allylaminocarbonyl, 2-methylallylaminocarbonyl, pyrrolidin-1-ylcarbonyl, ethylaminocarbonyl, phenylaminocarbonyl, indan-1-ylaminocarbonyl, 2-methoxyethylaminocarbonyl, indan-5-ylaminocarbonyl, 3,4-difluorophenyl-aminocarbonyl, 5-methylisoxazol-5-ylaminocarbonyl, 3-fluorophenylaminocarbonyl, 4-fluorophenylaminocarbonyl, *N*-methyl-*N*-phenylaminocarbonyl, 2-propylamino-carbonyl, 2-phenylpropylaminocarbonyl, *n*-propylaminocarbonyl, *N*-ethyl-*N*-(*n*-butyl)aminocarbonyl, benzylaminocarbonyl, thiazolidin-1-ylcarbonyl, piperazin-1-yl-carbonyl, piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, homopiperdin-1-ylcarbonyl, pyrimidin-2-ylaminocarbonyl, 4-methylpiperazin-1-ylcarbonyl, 4-methylpyrimidin-2-ylaminocarbonyl, pyrimidin-4-ylaminocarbonyl, pyrazin-2-ylaminocarbonyl, imidazol-2-ylaminocarbonyl.

In particular, R₇ is piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, ethylaminocarbonyl, phenylaminocarbonyl, pyrimidin-2-ylaminocarbonyl, or thiazol-2-ylaminocarbonyl.

More particularly, R₇ is piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, ethylaminocarbonyl or thiazol-2-ylaminocarbonyl. The stereochemistry at the C₂ carbon atom of the pyrrolidine ring, i.e., carbon carrying the R₇ group is either (*R*) or (*S*), preferably (*S*); or

(b) R₇ is -NHC(=O)OR₁₄ where R₁₄ is hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, or -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1.

Preferably, R₇ is -NHC(=O)OR₁₄ where R₁₄ is hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, heteroaryl; or

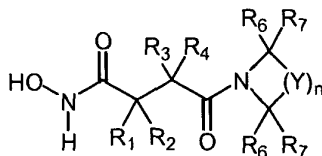
(c) R₇ is -C(=O)OR₁₄ where R₁₄ is hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, or -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1.

Preferably, R₇ is -C(=O)OR₁₄ where R₁₄ is hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, or heteroaryl.

More preferably, -C(=O)OR₁₄ where R₁₄ is alkyl, even more preferably R₇ is *tert*-butoxycarbonyl. The stereochemistry at the C₂ carbon atom of the pyrrolidine ring, i.e., carbon carrying the R₇ group is either (*R*) or (*S*), preferably (*S*).

The above defined embodiments of (i) - (iv) are employed either singularly or in any combination.

(B) Another preferred group of compounds is represented as Formula (IIa):



(IIa)

wherein:

- 5 R_1 is -OH, -OR₉, -R₈OR₉, -SH, -SR₉, -NH₂, -NHR₉, -NR₉R₁₀, -NHC(=O)H, -NR₉C(=O)H, -NHC(=O)R₉, -NR₉C(=O)R₁₀, -NHC(=O)NH₂, -NR₉C(=O)NH₂, -NHC(=O)NHR₉, -NHC(=O)NR₉R₁₀, -NR₉C(=O)NR_{9a}R₁₀, -NHC(=O)OR₉, -NR₉C(=O)OR₁₀, -NHS(=O)₂R₉, -NR₉S(=O)₂R₁₀, -NHS(=O)₂OR₉, or -NR₉S(=O)₂OR₁₀ where R₈ is selected from the group consisting of -C₁-C₁₂ alkylene,
- 10 -C₁-C₁₂ alkenylene, and -C₁-C₁₂ alkynylene and R₉, R_{9a} and R₁₀ are independently selected from the group consisting of -C₁-C₁₂ alkyl, -C₁-C₁₂ alkenyl, and -C₁-C₁₂ alkynyl;
- R_2 is hydrogen or -R₉ where R₉ is as defined above;
- R_3 is -R₁₁, -OH, -OR₁₁, -R₁₂OR₁₁, -SH, -SR₁₁, -NH₂, -NHR₁₁, -NR₁₁R₁₃,
- 15 -NHC(=O)H, -NR₁₁C(=O)H, -NHC(=O)R₁₁, -NR₁₁C(=O)R₁₃, -NHC(=O)NH₂, -NR₁₁C(=O)NH₂, -NHC(=O)NHR₁₁, -NHC(=O)NR₁₁R₁₃, -NR₁₁C(=O)NR_{11a}R₁₃, -NHC(=O)OR₁₁, -NR₁₁C(=O)OR₁₃, -NHS(=O)₂R₁₃, -NR₁₁S(=O)₂R₁₃, -NHS(=O)₂OR₁₁, or -NR₁₁S(=O)₂OR₁₃, where R₁₂ is selected from the group consisting of -C₁-C₁₂ alkylene, substituted alkylene, or heteroalkylene, -C₁-C₁₂
- 20 alkenylene, substituted alkenylene, or heteroalkenylene, -C₁-C₁₂ alkynylene, substituted alkynylene, or heteroalkynylene, and -(C₁-C₈ alkylene or substituted alkylene)_{n5}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n6} where n₅ and n₆ are independently 0 or 1; and R₁₁, R_{11a}, and R₁₃ are independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl,
- 25 -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n7}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n8} where n₇ and n₈ are independently 0 or 1;

R₄ is hydrogen or R₁₁ where R₁₁ is as defined above;

n is an integer from 1 to 5;

zero or one Y is selected from the group consisting of -O-, -NR₁₁- where R₁₁ is as defined above, and -S-, and all remaining Y are -CR₆R₇- where R₆ and R₇ are each independently selected from the group consisting of hydrogen, -R₁₄, -OH, -OR₁₄, -SH, -SR₁₄, -NH₂, -NHR₁₄, -NR₁₄R₁₅, -C(=O)H, -C(=O)R₁₄, -C(=O)NH₂, -C(=O)NHR₁₄, -C(=O)NR₁₄R₁₅, -C(=O)OH, -C(=O)OR₁₄, -C(=O)SH, -C(=O)SR₁₄, -C(=O)CH₃, -C(=O)CH₂R₁₄, -C(=O)CHR₁₄R₁₅, -C(=O)CR₁₄R₁₅R₁₆, -C(=O)OCH₃, -C(=O)OCH₂R₁₄, -C(=O)OCHR₁₄R₁₅, -C(=O)OCR₁₄R₁₅R₁₆, -S(=O)₂NH₂, -S(=O)₂NHR₁₄, -S(=O)₂NR₁₄R₁₅, -NHC(=O)H, -N(R₁₄)C(=O)H, -NHC(=O)R₁₅, -N(R₁₄)C(=O)R₁₅, -NHS(=O)₂H, -N(R₁₄)S(=O)₂H, -NHS(=O)₂OR₁₅, -N(R₁₄)S(=O)₂OR₁₅, -N(H)S(=O)₂R₁₅, -N(R₁₄)S(=O)₂R₁₅ and where two vicinal R₆ or R₇ groups combine to form a substituted or unsubstituted C₄-C₁₀ cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group; where R₁₄, R₁₅ and R₁₆ are each independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1; or a pharmaceutically acceptable salt thereof.

20 Within this group of compounds (IIa), a preferred group of compounds is that wherein the embodiments of (i) - (iv) defined below are employed either singularly or in any combination:

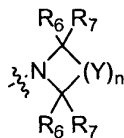
(i) A preferred group of compounds is that wherein R₁ is hydrogen or hydroxy and the stereochemistry at the carbon carrying the R₁ group is (*R*) or (*S*), preferably (*S*).

(ii) Another preferred group of compounds is that wherein R₂ and R₄ are hydrogen.

(iii) Another preferred group of compounds is that wherein R₃ is hydrogen or R₉ where R₉ is -C₁-C₁₂ alkyl or -(C₁-C₈ alkylene)_{n7}-(C₃-C₁₂ aryl or heteroaryl) where n₇, preferably methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *iso*-butyl, *tert*-butyl, *n*-pentyl, *iso*-pentyl, *neo*-pentyl, *n*-hexyl, 2-, 3-, 4-, or 5-methylpentyl, 4,4-dimethylbutyl, benzyl, 3-phenylpropyl, 2-phenylethyl, or 4-phenylbutyl, more

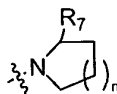
preferably *n*-butyl. The stereochemistry at the carbon carrying the R₃ group is (*R*) or (*S*), preferably (*R*).

(iv) Another preferred group of compounds is that wherein the



5

group is a group of formula:



wherein:

n is 1 or 2, preferably 1; and

10

R₇ is:

(a) -C(=O)NR₁₄R₁₅ where R₁₄ and R₁₅ are independently selected from the group consisting of hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1.

15

Preferably, R₇ is -C(=O)NR₁₄R₁₅ where R₁₄ and R₁₅ are each independently hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, heteroaryl. More preferably, R₇ is -C(=O)NHR₁₅ where R₁₅ is H or -(C₁-C₁₂) alkyl, aryl, or heteroaryl.

20

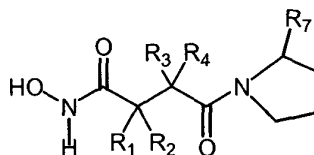
Even more preferably R₇ is *n*-butylaminocarbonyl, *tert*-butylaminocarbonyl, benzylaminocarbonyl, 1,1-dimethylpropylaminocarbonyl, 2-(cyclohexen-1-yl)-ethylaminocarbonyl, indan-5-ylaminocarbonyl, 4,5-dimethylthiazol-2-ylaminocarbonyl, 4-phenoxyphenylaminocarbonyl, cyclopropylmethylaminocarbonyl, pyridin-2-ylaminocarbonyl, pyridin-3-ylaminocarbonyl, pyridin-4-ylmethyl-

- aminocarbonyl, 3,4-methylenedioxyphenylaminocarbonyl, quinolin-3-ylaminocarbonyl, methylaminocarbonyl, 4-biphenylaminocarbonyl, 3-phenoxyphenylaminocarbonyl, 3,4-dichlorophenylaminocarbonyl, 4-*tert*-butylphenylaminocarbonyl, 4-*tert*-butylaminocarbonyl, indan-2-ylaminocarbonyl,
- 5 2,2-dimethylpropylaminocarbonyl, 4-phenylthiazol-2-ylaminocarbonyl, 5-phenylthiadiazol-2-ylaminocarbonyl, 5-ethylthiadiazol-3-ylaminocarbonyl, thiadiazol-2-ylaminocarbonyl, 3-trifluoromethoxyphenylaminocarbonyl, 2,5-dimethylphenylaminocarbonyl, 2,5-dimethoxyphenylamino-*carbonyl*, 3,4-dichlorophenylaminocarbonyl, benzthiazol-2-ylaminocarbonyl,
- 10 3-phenoxyphenylaminocarbonyl, 2-hydroxybutylaminocarbonyl, 4-hydroxybutylaminocarbonyl, 1,4-benzodioxan-6-ylaminocarbonyl, isoquinolin-6-ylaminocarbonyl, methylaminocarbonyl, thiazol-2-ylaminocarbonyl, 4-methylthiazol-2-ylaminocarbonyl, 3-methylbutylaminocarbonyl, *n*-pentylaminocarbonyl, cyclohexylaminocarbonyl, 5-methylthiazol-2-ylaminocarbonyl, 4-methylthiazol-2-ylaminocarbonyl, 2,4-dimethoxyphenylaminocarbonyl, 3,4-methylenedioxyphen-5-ylmethylaminocarbonyl, allylaminocarbonyl, 2-methylallylaminocarbonyl,
- 15 ethylaminocarbonyl, phenylaminocarbonyl, indan-1-ylaminocarbonyl, 2-methoxyethylaminocarbonyl, indan-5-ylaminocarbonyl, 3,4-difluorophenylaminocarbonyl, 5-methylisoxazol-5-ylaminocarbonyl, 3-fluorophenylaminocarbonyl,
- 20 4-fluorophenylaminocarbonyl, *N*-methyl-*N*-phenylaminocarbonyl, 2-propylaminocarbonyl, 2-phenylpropylaminocarbonyl, *n*-propylaminocarbonyl, *N*-ethyl-*N*-(*n*-butyl)aminocarbonyl, benzylaminocarbonyl, thiazolidin-1-ylcarbonyl, pyrimidin-2-ylaminocarbonyl, 4-methylpyrimidin-2-ylaminocarbonyl, pyrimidin-4-ylaminocarbonyl, pyrazin-2-ylaminocarbonyl, imidazol-2-ylaminocarbonyl.
- 25 In particular, R₇ is ethylaminocarbonyl, phenylaminocarbonyl, pyrimidin-2-ylaminocarbonyl, or thiazol-2-ylaminocarbonyl. More particularly, R₇ is phenylaminocarbonyl or pyrimidin-2-ylaminocarbonyl. The stereochemistry at the C2 carbon atom of the pyrrolidine ring, i.e., carbon carrying the R₇ group is either (*R*) or (*S*), preferably (*S*); or
- 30 (b) -NHC(=O)OR₁₄ where R₁₄ is hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, or -(C₁-C₈ alkyl or

substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1. Preferably, R₇ is -NHC(=O)OR₁₄ where R₁₄ is hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, heteroaryl; or

- (c) -C(=O)OR₁₄ where R₁₄ is hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, or -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1. Preferably, R₇ is -C(=O)OR₁₄ where R₁₄ is hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, or heteroaryl. More preferably, -C(=O)OR₁₄ where R₁₄ is alkyl, even more preferably R₇ is *tert*-butoxycarbonyl. The stereochemistry at the C2 carbon atom of the pyrrolidine ring, i.e., carbon carrying the R₇ group is either (*R*) or (*S*), preferably (*S*).

(C) Another preferred group of compounds is represented by Formula (IIb):



(IIb)

wherein:

- R₁ is -R₉, -OH, -OR₉, -R₈OR₉, -SH, -SR₉, -NH₂, -NHR₉, -NR₉R₁₀, -NHC(=O)H, -NR₉C(=O)H, -NHC(=O)R₉, -NR₉C(=O)R₁₀, -NHC(=O)NH₂, -NR₉C(=O)NH₂, -NHC(=O)NHR₉, -NHC(=O)NR₉R₁₀, -NR₉C(=O)NR₉R₁₀, -NHC(=O)OR₉, -NR₉C(=O)OR₁₀, -NHS(=O)₂R₉, -NR₉S(=O)₂R₁₀, -NHS(=O)₂OR₉, or -NR₉S(=O)₂OR₁₀ where R₈ is selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n1}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n2} where n₁ and n₂ are independently 0 or 1; and R₉, R_{9a}, and R₁₀ are each independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂

alkynyl, substituted alkynyl, or heteroalkynyl, and $-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n3}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n4}$ where $n3$ and $n4$ are independently 0 or 1;

R_2 is -H or $-R_9$ where R_9 is as defined above;

- 5 R_3 is $-R_{11}$, $-OH$, $-OR_{11}$, $-R_{12}OR_{11}$, $-SH$, $-SR_{11}$, $-NH_2$, $-NHR_{11}$, $-NR_aR_b$,
 $-NHC(=O)H$, $-NR_{11}C(=O)H$, $-NHC(=O)R_{11}$, $-NR_{11}C(=O)R_{13}$, $-NHC(=O)NH_2$,
 $-NR_{11}C(=O)NH_2$, $-NHC(=O)NHR_{11}$, $-NHC(=O)NR_{11}R_{13}$, $-NR_{11}C(=O)NR_{11a}R_{13}$,
 $-NHC(=O)OR_{11}$, $-NR_{11}C(=O)OR_{13}$, $-NHS(=O)_2R_{11}$, $-NR_{11}S(=O)_2R_{13}$,
 $-NHS(=O)_2OR_{11}$, or $-NR_{11}S(=O)_2OR_{13}$ where R_{12} is selected from the group
10 consisting of $-C_1-C_{12}$ alkylene, substituted alkylene, or heteroalkylene,
 $-C_1-C_{12}$ alkenylene, substituted alkenylene, or heteroalkenylene, $-C_1-C_{12}$ alkynylene,
substituted alkynylene, or heteroalkynylene, and $-(C_1-C_8$ alkylene or substituted
alkylene) $_{n5}$ $-(C_3-C_{12}$ arylene or heteroarylene) $-(C_1-C_8$ alkyl or substituted alkyl) $_{n6}$
where $n5$ and $n6$ are independently 0 or 1; and R_{11} , R_{11a} , and R_{13} are independently
15 selected from the group consisting of $-C_1-C_{12}$ alkyl, substituted alkyl, or heteroalkyl,
 $-C_1-C_{12}$ alkenyl, substituted alkenyl, or heteroalkenyl, $-C_1-C_{12}$ alkynyl, substituted
alkynyl, or heteroalkynyl, and $-(C_1-C_8$ alkyl or substituted alkyl) $_{n7}$ $-(C_3-C_{12}$ arylene or
heteroarylene) $-(C_1-C_8$ alkyl or substituted alkyl) $_{n8}$ where $n7$ and $n8$ are independently
0 or 1;
- 20 R_4 is hydrogen or $-R_{11}$ where R_{11} is as defined above;
 R_7 is $-C(=O)H$, $-C(=O)R_{14}$, $-C(=O)NH_2$, $-C(=O)NHR_{14}$, $-C(=O)NR_{14}R_{15}$,
 $-C(=O)SH$, or $-C(=O)SR_{14}$ where R_{14} and R_{15} are independently selected from
the group consisting of $-C_1-C_{12}$ alkyl, substituted alkyl, or heteroalkyl, $-C_1-C_{12}$
alkenyl, substituted alkenyl, or heteroalkenyl, $-C_1-C_{12}$ alkynyl, substituted alkynyl, or
25 heteroalkynyl, and $-(C_1-C_8$ alkyl or substituted alkyl) $_{n9}$ $-(C_3-C_{12}$ arylene or
heteroarylene) $-(C_1-C_8$ alkyl or substituted alkyl) $_{n10}$ where $n9$ and $n10$ are
independently 0 or 1; and where R_7 is $-C(=O)NR_{14}R_{15}$, then the R_{14} and R_{15} groups
additionally can combine to form a substituted or unsubstituted C_4-C_{10} cyclic alkyl,
cyclic heteroalkyl, aryl or heteroaryl group; or
30 a pharmaceutically acceptable salt thereof.

Within this group of compounds, a preferred group of compounds is that wherein the embodiments of (i) - (iv) defined below are employed either singularly or in any combination:

(i) A preferred group of compounds is that wherein R₁ is hydroxy and the stereochemistry at the carbon carrying the R₁ group is (*R*) or (*S*), preferably (*S*).

(ii) Another preferred group of compounds is that wherein R₂ is hydrogen.

(iii) Another preferred group of compounds is that wherein R₃ is hydrogen or R₉ where R₉ is -C₁-C₁₂ alkyl or -(C₁-C₈ alkylene)_{n5}-(C₃-C₁₂ aryl or heteroaryl) where n₅ is 0 or 1, preferably methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *iso*-butyl, *tert*-butyl, *n*-pentyl, *iso*-pentyl, *neo*-pentyl, *n*-hexyl, 2-, 3-, 4-, or 5-methylpentyl, 4-dimethylbutyl, benzyl, 3-phenylpropyl, 2-phenylethyl, or 4-phenylbutyl, more preferably *n*-butyl. The stereochemistry at the carbon carrying the R₃ group is (*R*) or (*S*), preferably (*R*).

(iv) Yet another preferred group of compounds is that wherein R₇ is:

(a) -C(=O)NHR₁₄ where R₁₄ is selected from the group consisting of -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1. Preferably, R₇ is -C(=O)NHR₁₄ where R₁₄ is -(C₁-C₁₂) alkyl, alkoxy, aryl, or heteroaryl. More preferably, R₇ is -C(=O)NHR₁₄ where R₁₄ is -(C₁-C₁₂) alkyl, aryl, or heteroaryl. Even more preferably R₇ is *n*-butylaminocarbonyl, *tert*-butylaminocarbonyl, benzylaminocarbonyl, 1,1-dimethylpropylaminocarbonyl, 2-(cyclohexen-1-yl)-ethylaminocarbonyl, indan-5-ylaminocarbonyl, 4,5-dimethylthiazol-2-ylaminocarbonyl, 4-phenoxyphenylaminocarbonyl, cyclopropylmethylaminocarbonyl, pyridin-2-ylaminocarbonyl, pyridin-3-ylaminocarbonyl, pyridin-4-ylmethylaminocarbonyl, morpholin-4-ylcarbonyl, 3,4-methylenedioxyphenylaminocarbonyl, quinolin-3-ylaminocarbonyl, methylaminocarbonyl, 4-biphenylaminocarbonyl, 3-phenoxyphenylaminocarbonyl, 3,4-dichlorophenylaminocarbonyl, 4-*tert*-butylphenylaminocarbonyl, 4-*tert*-butylaminocarbonyl, indan-2-ylaminocarbonyl, 2,2-dimethylpropylaminocarbonyl, 4-phenylthiazol-2-ylaminocarbonyl, 5-phenylthiadiazol-2-ylaminocarbonyl, 5-ethylthiadiazol-3-ylamino-

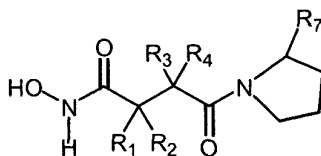
carbonyl, thiadiazol-2-ylaminocarbonyl, 3-trifluoromethoxyphenyl-aminocarbonyl, 2,5-dimethylphenylaminocarbonyl, 2,5-dimethoxyphenylamino-carbonyl, 3,4-dichlorophenylaminocarbonyl, benzthiazol-2-ylaminocarbonyl, 3-phenoxyphenylaminocarbonyl, 2-hydroxybutylaminocarbonyl, 4-hydroxybutyl-aminocarbonyl, 1,4-benzodioxan-6-ylaminocarbonyl, isoquinolin-6-ylaminocarbonyl, methylaminocarbonyl, thiazol-2-ylaminocarbonyl, 4-methylthiazol-2-ylaminocarbonyl, 3-methylbutyl-aminocarbonyl, *n*-pentylaminocarbonyl, cyclohexylaminocarbonyl, 5-methylthiazol-2-ylaminocarbonyl, 4-methylthiazol-2-ylaminocarbonyl, 2,4-dimethoxyphenyl-aminocarbonyl, 3,4-methylenedioxyphen-5-ylmethylaminocarbonyl, allylaminocarbonyl, 2-methylallylaminocarbonyl, pyrrolidin-1-ylcarbonyl, ethylaminocarbonyl, phenylaminocarbonyl, indan-1-ylaminocarbonyl, 2-methoxyethylaminocarbonyl, indan-5-ylaminocarbonyl, 3,4-difluorophenylaminocarbonyl, 5-methylisoxazol-5-ylaminocarbonyl, 3-fluorophenylaminocarbonyl, 4-fluorophenylaminocarbonyl, *N*-methyl-*N*-phenylaminocarbonyl, 2-propylaminocarbonyl, 2-phenylpropylaminocarbonyl, *n*-propylaminocarbonyl, *N*-ethyl-*N*-(*n*-butyl)aminocarbonyl, benzylaminocarbonyl, thiazolidin-1-ylcarbonyl, piperazin-1-ylcarbonyl, piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, homopiperidin-1-ylcarbonyl, pyrimidin-2-ylaminocarbonyl, 4-methylpiperazin-1-ylcarbonyl, 4-methylpyrimidin-2-ylaminocarbonyl, pyrimidin-4-ylaminocarbonyl, pyrazin-2-ylaminocarbonyl, imidazol-2-ylaminocarbonyl. In particular, R₇ is piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, ethylaminocarbonyl, phenylaminocarbonyl, pyrimidin-2-ylaminocarbonyl, or thiazol-2-ylaminocarbonyl.

More particularly, R₇ is phenylaminocarbonyl or pyrimidin-2-ylaminocarbonyl. The stereochemistry at the C2 carbon atom of the pyrrolidine ring, i.e., carbon carrying the R₇ group is either (*R*) or (*S*), preferably (*S*); or

(b) R₇ is -C(=O)OR₁₄ where R₁₄ is selected from the group consisting of hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1. Preferably, R₇ is -C(=O)OR₁₄ where R₁₄ is hydrogen, -(C₁-C₁₂) alkyl, alkoxy, aryl, or heteroaryl. More preferably, -C(=O)OR₁₄ where R₁₄ is alkyl,

even more preferably R_7 is *tert*-butoxycarbonyl. The stereochemistry at the C2 carbon atom of the pyrrolidine ring, i.e., carbon carrying the R_7 group is either (*R*) or (*S*), preferably (*S*).

- 5 (D) Another preferred group of compounds is represented by Formula (IIc):



(IIc)

- 10 wherein:

R_1 is -OH, -OR₉, -SH or -SR₉ wherein R_9 is selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n1}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n2} where n_1 and n_2 are independently 0 or 1;

R_2 is hydrogen;

- 20 R_3 is -R₁₁, -OH, -OR₁₁, -R₁₂OR₁₁, -SH, -SR₁₁, -NH₂, -NHR₁₁, -NR₁₁R₁₃, -NHC(=O)H, -NR₁₁C(=O)H, -NHC(=O)R₁₁, -NR₁₁C(=O)R₁₃, -NHC(=O)NH₂, -NR₁₁C(=O)NH₂, -NHC(=O)NHR₁₁, -NHC(=O)NR₁₁R₁₃, -NR₁₁C(=O)NR_{11a}R₁₃, -NHC(=O)OR₁₁, -NR₁₁C(=O)OR₁₃, -NHS(=O)₂R₁₁, -NR₁₁S(=O)₂R₁₃, -NHS(=O)₂OR₁₁, or -NR₁₁S(=O)₂OR₁₃ where R_{12} is selected from the group consisting of -C₁-C₁₂ alkylene, substituted alkylene, or heteroalkylene, -C₁-C₁₂ alkenylene, substituted alkenylene, or heteroalkenylene, -C₁-C₁₂ alkynylene, substituted alkynylene, or heteroalkynylene, and -(C₁-C₈ alkylene or substituted alkylene)_{n5}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n6} where n_5 and n_6 are independently 0 or 1; and R_{11} and R_{13} are independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂

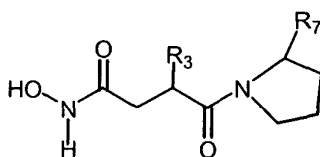
alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n7}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n8} where n7 and n8 are independently 0 or 1;

5 R₄ is hydrogen or -R₁₁ wherein R₁₁ is as defined above; and

R₇ is -C(=O)OR₁₄, where R₁₄ is selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n9 and n10 are independently 0 or 1; or
10 a pharmaceutically acceptable salt thereof.

In another embodiment of this series of compounds, R₁ is -OH or -OR₉. In another embodiment of this series of compounds, R₃ is -C₁-C₁₂ alkyl, such as C₄ alkyl and R₄ is H. In another embodiment of this series of compounds, R₁₄ is -C(=O)O-C₁-
15 C₁₂ alkyl, such as -C(=O)O-C₁-C₄ alkyl, for example -C(=O)O-t-butyl.

(E) Another preferred group of compounds if represented by Formula (IIId):



(IIId)

20 wherein:

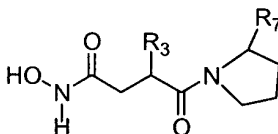
R₃ is -R₁₁ where R₁₁ is selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n7}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n8} where n7 and n8 are independently 0 or 1; and
25

R₇ is -C(=O)OR₁₄ where R₁₄ is selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈

alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1; or a pharmaceutically acceptable salt thereof.

In one embodiment, R₃ is -(C₁-C₁₂)alkyl, preferably *n*-butyl. In another embodiment of this series of compounds, R₇ is -C(O)O-C₁-C₁₂ alkyl, such as -C(O)O-C₁-C₄ alkyl, for example -C(O)O-*tert*-butyl.

(F) Another preferred group of compounds is represented by Formula (Ile):



(Ile)

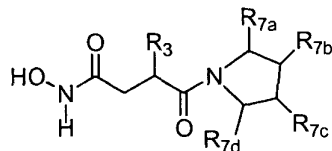
wherein:

R₃ is -R₁₁ where -R₁₁ is selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n7}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n8} where n₇ and n₈ are independently 0 or 1;

R₇ is -NH₂, -NHR₁₃, or -NHR₁₄R₁₅ where R₁₃, R₁₄ and R₁₅ are independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1; or where R₁₄ and R₁₅ combine to form a substituted or unsubstituted C₄-C₁₀ cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group; or a pharmaceutically acceptable salt thereof.

In one embodiment of this series of compounds, R₃ is C₁-C₁₂ alkyl, preferably *n*-butyl. In another embodiment of this series of compounds, R₇ is -NHR₁₃ where R₁₃ is as defined above.

(G) Another preferred group of compounds is represented by Formula (IIf):



(IIf)

5 wherein:

R₃ is -R₁₁ wherein R₁₁ is selected from the group consisting of hydrogen, -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n7}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or

10 substituted alkyl)_{n8} where n₇ and n₈ are independently 0 or 1;

R_{7a}, R_{7b}, R_{7c} and R_{7d} are independently selected from the group consisting of hydrogen, -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or

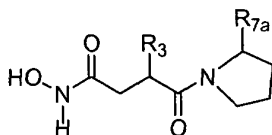
15 substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1; or two vicinal R₇ groups can combine to form a substituted or unsubstituted C₄-C₁₀ cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group; or a pharmaceutically acceptable salt thereof.

In one embodiment of this series of compounds, R₃ is *n*-butyl. In another embodiment of this series of compounds, at least one R₇ is selected from the group consisting of -C(=O)OR₁₄, -OH, -OR₁₄, -R₁₄, -NH(C=O)OR₁₄, or -NH(C=O)R₁₅, where R₁₄ and R₁₅ are independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and (C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted

20

25 alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1.

(H) Another preferred group of compounds is represented by Formula (IIg):



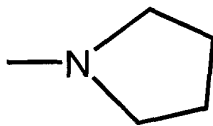
(IIg)

wherein:

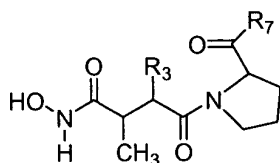
R_3 is $-R_{11}$ where R_{11} is selected from the group consisting of hydrogen, $-C_1-$
 5 C_{12} alkyl, substituted alkyl, or heteroalkyl, $-C_1-C_{12}$ alkenyl, substituted alkenyl, or
 heteroalkenyl, $-C_1-C_{12}$ alkynyl, substituted alkynyl, or heteroalkynyl, and $-(C_1-C_8$
 alkyl or substituted alkyl) $_{n7}$ -(C_3-C_{12} arylene or heteroarylene)-(C_1-C_8 alkyl or
 substituted alkyl) $_{n8}$ where n_7 and n_8 are independently 0 or 1; and

R_{7a} is selected from the group consisting of hydrogen, $-C_1-C_{12}$ alkyl,
 10 substituted alkyl, or heteroalkyl, $-C_1-C_{12}$ alkenyl, substituted alkenyl, or
 heteroalkenyl, $-C_1-C_{12}$ alkynyl, substituted alkynyl, or heteroalkynyl, and $-(C_1-C_8$
 alkyl or substituted alkyl) $_{n9}$ -(C_3-C_{12} arylene or heteroarylene)-(C_1-C_8 alkyl or
 substituted alkyl) $_{n10}$ where n_9 and n_{10} are independently 0 or 1; or a pharmaceutically
 acceptable salt thereof.

15 In another embodiment of this series of compounds, R_{7a} is $-CH_2-R_d$ where R_d
 is selected from the group consisting of H, $-C_1-C_{12}$ alkyl, substituted alkyl, or
 heteroalkyl, $-C_1-C_{12}$ alkenyl, substituted alkenyl, or heteroalkenyl, $-C_1-C_{12}$ alkynyl,
 substituted alkynyl, or heteroalkynyl, and $-(C_1-C_8$ alkyl or substituted alkyl) $_{n9}$ -(C_3-C_{12}
 arylene or heteroarylene)-(C_1-C_8 alkyl or substituted alkyl) $_{n10}$ where n_9 and n_{10} are
 20 independently 0 or 1. In another embodiment of this series of compounds, R_d is
 selected from the group consisting of $-O-CH_3$, $-OH$, $-NH-(C=O)-CH_3$, and



(I) Another preferred group of compounds is represented by Formula (IIh):



(IIh)

wherein:

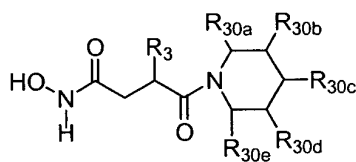
R₃ is -R₁₁ where R₁₁ is selected from the group consisting of hydrogen, -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n7}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n8} where n₇ and n₈ are independently 0 or 1; and

R₇ is selected from the group consisting of -R₁₄ or -OR₁₄ where R₁₄ is selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1; or

a pharmaceutically acceptable salt thereof.

In one embodiment of this series of compounds, R₃ is *n*-butyl. In another embodiment of this series of compounds, R₇ is -OCH₃ or -O-*tert*-butyl.

(J) Another preferred group of compounds is represented by Formula (IIi):



(IIi)

wherein:

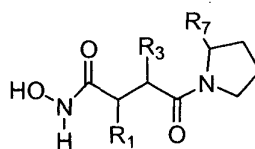
R₃ is -R₁₁ where R₁₁ is hydrogen, -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl,

substituted alkynyl, or heteroalkynyl, or $-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n7}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n8}$ where $n7$ and $n8$ are independently 0 or 1; and

- R_{30a} , R_{30b} , R_{30c} , R_{30d} , and R_{30e} are independently selected from the group consisting of hydrogen, $-C_1-C_{12}$ alkyl, substituted alkyl, or heteroalkyl, $-C_1-C_{12}$ alkenyl, substituted alkenyl, or heteroalkenyl, $-C_1-C_{12}$ alkynyl, substituted alkynyl, or heteroalkynyl, and $-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n9}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n10}$ where $n9$ and $n10$ are independently 0 or 1; or where two vicinal R_{30} groups can combine to form a substituted or unsubstituted C_4-C_{10} cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group; and all salts and stereoisomers thereof.

- In one embodiment of this series of compounds, at least one R_{30} is selected from the group consisting of $-C(=O)OR_{15}$ and $-C(=O)R_{15}$, where R_{15} is independently selected from the group consisting of C_1-C_{12} alkyl, substituted alkyl, or heteroalkyl, C_1-C_{12} alkenyl, substituted alkenyl, or heteroalkenyl, C_1-C_{12} alkynyl, substituted alkynyl, or heteroalkynyl, and $(C_1-C_8 \text{ alkyl or substituted alkyl})_{n9}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n10}$ where $n9$ and $n10$ are independently 0 or 1.

- (K) Another preferred group of compounds if represented by Formula (IIj):



(IIj)

where:

- R_1 is halo;
- R_3 is hydrogen, R_{11} , $-OH$, $-OR_{11}$, $-R_{12}OR_{11}$, $-SH$, $-SR_{11}$, $-NH_2$, $-NHR_{11}$, $-NR_{11}R_{13}$, $-NHC(=O)H$, $-NR_{11}C(=O)H$, $-NHC(=O)R_{11}$, $-NR_{11}C(=O)R_{13}$, $-NHC(=O)NH_2$, $-NR_{11}C(=O)NH_2$, $-NHC(=O)NHR_{11}$, $-NHC(=O)NR_{11}R_{13}$, $-NR_{11}C(=O)NR_{11a}R_{13}$, $-NHC(=O)OR_{11}$, $-NR_{11}C(=O)OR_{13}$, $-NHS(=O)_2R_{13}$,

-NR₁₁S(=O)₂R₁₃, -NHS(=O)₂OR₁₁, or -NR₁₁S(=O)₂OR₁₃, where R₁₂ is selected from the group consisting of -C₁-C₁₂ alkylene, substituted alkylene, or heteroalkylene, -C₁-C₁₂ alkenylene, substituted alkenylene, or heteroalkenylene, -C₁-C₁₂ alkynylene, substituted alkynylene, or heteroalkynylene, and -(C₁-C₈ alkylene or substituted alkylene)_{n5}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n6} where n₅ and n₆ are independently 0 or 1; and R₁₁, R_{11a} and R₁₃ are independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n7}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n8} where n₇ and n₈ are independently 0 or 1;

R₇ is hydrogen, R₁₄, -OH, -OR₁₄, -SH, -SR₁₄, -NH₂, -NHR₁₄, -NR₁₄R₁₅, -C(=O)H, -C(=O)R₁₄, -C(=O)NH₂, -C(=O)NHR₁₄, -C(=O)NR₁₄R₁₅, -C(=O)OH, -C(=O)OR₁₄, -C(=O)SH, -C(=O)SR₁₄, -C(=O)CH₃, -C(=O)CH₂R₁₄, -C(=O)CHR₁₄R₁₅, -C(=O)CR₁₄R₁₅R₁₆, -C(=O)OCH₃, -C(=O)OCH₂R₁₄, -C(=O)OCHR₁₄R₁₅, -C(=O)OCR₁₄R₁₅R₁₆, -S(=O)₂NH₂, -S(=O)₂NHR₁₄, -S(=O)₂NR₁₄R₁₅, -NHC(=O)H, -N(R₁₄)C(=O)H, -NHC(=O)R₁₅, -N(R₁₄)C(=O)R₁₅, -NHC(=O)OR₁₄, -NHS(=O)₂H, -N(R₁₄)S(=O)₂H, -NHS(=O)₂OR₁₅, -N(R₁₄)S(=O)₂OR₁₅, -N(H)S(=O)₂R₁₅, or -N(R₁₄)S(=O)₂R₁₅, or where two vicinal R₆ or R₇ groups combine to form a substituted or unsubstituted -C₄-C₁₀ cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group where R₁₄, R₁₅ and R₁₆ are each independently selected from the group consisting of -C₁-C₁₂ alkyl, substituted alkyl, or heteroalkyl, -C₁-C₁₂ alkenyl, substituted alkenyl, or heteroalkenyl, -C₁-C₁₂ alkynyl, substituted alkynyl, or heteroalkynyl, and -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n₉ and n₁₀ are independently 0 or 1; or when R₁₄ and R₁₅ are attached to a nitrogen atom they can combine to form a substituted or unsubstituted C₄-C₁₀ cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group; or a pharmaceutically acceptable salt thereof.

Within this group of compounds, a preferred group of compounds is that wherein the embodiments of (i) - (iii) defined below are employed either singularly or in any combination:

(i) A preferred group of compounds is that wherein R_1 is fluoro. The stereochemistry at the carbon carrying the R_1 group is (*R*) or (*S*), preferably (*S*).

(ii) Another preferred group of compounds is that wherein R_3 is hydrogen or R_9 where R_9 is $-C_1-C_{12}$ alkyl or $-(C_1-C_8 \text{ alkylene})_{n5}-(C_3-C_{12} \text{ aryl or heteroaryl})$

5 where $n5$ is 0 or 1, preferably methyl, ethyl, *n*-propyl, *iso*-propyl, *n*-butyl, *iso*-butyl, *tert*-butyl, *n*-pentyl, *iso*-pentyl, *neo*-pentyl, *n*-hexyl, 2-, 3-, 4-, or 5-methylpentyl, 4,4-dimethylbutyl, benzyl, 3-phenylpropyl, 2-phenylethyl, or 4-phenylbutyl, more preferably *n*-butyl. The stereochemistry at the carbon carrying the R_3 group is (*R*) or (*S*), preferably (*R*); and

10 (iii) R_7 is:

(a) $-C(=O)NR_{14}R_{15}$, where R_{14} and R_{15} are independently hydrogen, $-(C_1-C_{12})$ alkyl, substituted alkyl, or heteroalkyl, $-(C_1-C_{12})$ alkenyl, substituted alkenyl, or heteroalkenyl, $-(C_1-C_{12})$ alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, or $-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n9}-(C_3-C_{12} \text{ arylene or heteroarylene})-(C_1-C_8 \text{ alkyl or substituted alkyl})_{n10}$ where $n9$ and $n10$ are independently 0 or 1; or R_{14} and R_{15} combine to form a substituted or unsubstituted $-(C_4-C_{10})$ cyclic alkyl, cyclic heteroalkyl, aryl or heteroaryl group.

20 Preferably, R_7 is $-C(=O)NR_{14}R_{15}$ where R_{14} and R_{15} are each independently hydrogen or $-(C_1-C_{12})$ alkyl, alkoxy, aryl, heteroaryl or R_{14} and R_{15} , when attached to the same carbon, combine to form a cyclic heteroalkyl, aryl or heteroaryl group. More preferably, R_7 is $-C(=O)NHR_{15}$ where R_{15} is H or $-(C_1-C_{12})$ alkyl, aryl, or heteroaryl or $-C(=O)NR_{14}R_{15}$ where R_{14} and R_{15} form a substituted or unsubstituted $-(C_4-C_{10})$ cyclic heteroalkyl.

25 Even more preferably R_7 is *n*-butylaminocarbonyl, *tert*-butylaminocarbonyl, benzylaminocarbonyl, 1,1-dimethylpropylaminocarbonyl, 2-(cyclohexen-1-yl)-ethylaminocarbonyl, indan-5-ylaminocarbonyl, 4,5-dimethylthiazol-2-ylaminocarbonyl, 4-phenoxyphenylaminocarbonyl, cyclopropylmethylaminocarbonyl, pyridin-2-ylaminocarbonyl, pyridin-3-ylaminocarbonyl, pyridin-4-ylmethylaminocarbonyl, morpholin-4-ylcarbonyl, 3,4-methylenedioxy-phenylaminocarbonyl, quinolin-3-ylaminocarbonyl, methylaminocarbonyl, 4-biphenylaminocarbonyl, 3-phenoxyphenylaminocarbonyl, 3,4-dichlorophenylaminocarbonyl, 4-*tert*-butylphenylaminocarbonyl, 4-*tert*-butylaminocarbonyl, indan-

2-ylaminocarbonyl, 2,2-dimethylpropylaminocarbonyl, 4-phenylthiazol-2-ylaminocarbonyl, 5-phenylthiadiazol-2-ylaminocarbonyl, 5-ethylthiadiazol-3-ylaminocarbonyl, thiadiazol-2-ylaminocarbonyl, 3-trifluoromethoxyphenylaminocarbonyl, 2,5-dimethylphenylaminocarbonyl, 2,5-dimethoxyphenylaminocarbonyl, 3,4-dichlorophenylaminocarbonyl, benzthiazol-2-ylaminocarbonyl, 3-phenoxyphenylaminocarbonyl, 2-hydroxybutylaminocarbonyl, 4-hydroxybutylaminocarbonyl, 1,4-benzodioxan-6-ylaminocarbonyl, isoquinolin-6-ylaminocarbonyl, methylaminocarbonyl, thiazol-2-ylaminocarbonyl, 4-methylthiazol-2-ylaminocarbonyl, 3-methylbutylaminocarbonyl, *n*-pentylaminocarbonyl, cyclohexylaminocarbonyl, 5-methylthiazol-2-ylaminocarbonyl, 4-methylthiazol-2-ylaminocarbonyl, 2,4-dimethoxyphenylaminocarbonyl, 3,4-methylenedioxyphen-5-ylmethylaminocarbonyl, allylaminocarbonyl, 2-methylallylaminocarbonyl, pyrrolidin-1-ylcarbonyl, ethylaminocarbonyl, phenylaminocarbonyl, indan-1-ylaminocarbonyl, 2-methoxyethylaminocarbonyl, indan-5-ylaminocarbonyl, 3,4-difluorophenylaminocarbonyl, 5-methylisoxazol-5-ylaminocarbonyl, 3-fluorophenylaminocarbonyl, 4-fluorophenylaminocarbonyl, *N*-methyl-*N*-phenylaminocarbonyl, 2-propylaminocarbonyl, 2-phenylpropylaminocarbonyl, *n*-propylaminocarbonyl, *N*-ethyl-*N*-(*n*-butyl)aminocarbonyl, benzylaminocarbonyl, thiazolidin-1-ylcarbonyl, piperazin-1-ylcarbonyl, piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, homopiperidin-1-ylcarbonyl, pyrimidin-2-ylaminocarbonyl, 4-methylpiperazin-1-ylcarbonyl, 4-methylpyrimidin-2-ylaminocarbonyl, pyrimidin-4-ylaminocarbonyl, pyrazin-2-ylaminocarbonyl, imidazol-2-ylaminocarbonyl.

In particular, R_7 is piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, ethylaminocarbonyl, phenylaminocarbonyl, pyrimidin-2-ylaminocarbonyl, or thiazol-2-ylaminocarbonyl.

More particularly, R_7 is piperidin-1-ylcarbonyl, azetidin-1-ylcarbonyl, ethylaminocarbonyl or thiazol-2-ylaminocarbonyl. The stereochemistry at the C2 carbon atom of the pyrrolidine ring, i.e., carbon carrying the R_7 group is either (*R*) or (*S*), preferably (*S*); or

(b) R_7 is $-NHC(=O)OR_{14}$ where R_{14} is hydrogen, $-(C_1-C_{12})$ alkyl, substituted alkyl, or heteroalkyl, $-(C_1-C_{12})$ alkenyl, substituted alkenyl, or heteroalkenyl, $-(C_1-C_{12})$ alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, or -

(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n9 and n10 are independently 0 or 1. Preferably, R₇ is -NHC(=O)OR₁₄ where R₁₄ is hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, heteroaryl; or

- (c) R₇ is -C(=O)OR₁₄ where R₁₄ is hydrogen, -(C₁-C₁₂) alkyl, substituted alkyl, or heteroalkyl, -(C₁-C₁₂) alkenyl, substituted alkenyl, or heteroalkenyl, -(C₁-C₁₂) alkynyl, substituted alkynyl, or heteroalkynyl, alkoxy, or -(C₁-C₈ alkyl or substituted alkyl)_{n9}-(C₃-C₁₂ arylene or heteroarylene)-(C₁-C₈ alkyl or substituted alkyl)_{n10} where n9 and n10 are independently 0 or 1. Preferably, R₇ is -C(=O)OR₁₇ where R₁₄ is hydrogen or -(C₁-C₁₂) alkyl, alkoxy, aryl, or heteroaryl. More preferably, -C(=O)OR₁₄ where R₁₄ is alkyl, even more preferably R₇ is *tert*-butoxycarbonyl. The stereochemistry at the C2 carbon atom of the pyrrolidine ring, i.e., carbon carrying the R₇ group is either (*R*) or (*S*), preferably (*S*).

Preferred compounds of the Invention are:

- 15 *N*-hydroxy-3-[(*S*)-(n-butyl)-3-(2-(*S*)-1,1-dimethylethyloxycarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide;
- 20 *N*-hydroxy-3-[(*S*)-(n-butyl)-3-(2-(*S*)-pyridin-1-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide;
- 25 *N*-hydroxy-3-[(*S*)-(n-butyl)-3-(2-(*S*)-azetidin-1-ylcarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide;
- 30 *N*-hydroxy-3-[(*S*)-(n-butyl)-3-(2-(*S*)-ethylaminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide;
- N*-hydroxy-3-[(*S*)-(n-butyl)-3-(2-(*S*)-phenylaminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide;
- N*-hydroxy-3-[(*S*)-(n-butyl)-3-(2-(*S*)-pyrimidin-2-ylaminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide; and
- N*-hydroxy-3-[(*S*)-(n-butyl)-3-(2-(*S*)-thiazol-2-ylaminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide.

GENERAL SYNTHETIC SCHEME

Compounds of this invention can be made by the methods depicted in the reaction schemes shown below.

The starting materials and reagents used in preparing these compounds are either available from commercial suppliers such as Aldrich Chemical Co., (Milwaukee, Wisconsin, USA), Bachem (Torrance, California, USA), Emka-Chemie, or Sigma (St. Louis, Missouri, USA) or are prepared by methods known to those skilled in the art following procedures set forth in references such as Fieser and Fieser's Reagents for Organic Synthesis, Volumes 1-15 (John Wiley and Sons, 1991); Rodd's Chemistry of Carbon Compounds, Volumes 1-5 and Supplementals (Elsevier Science Publishers, 1989), Organic Reactions, Volumes 1-40 (John Wiley and Sons, 1991), March's Advanced Organic Chemistry, (John Wiley and Sons, 4th Edition), and Larock's Comprehensive Organic Transformations (VCH Publishers Inc., 1989). These schemes are merely illustrative of some methods by which the compounds of this invention can be synthesized, and various modifications to these schemes can be made and will be suggested to one skilled in the art having referred to this disclosure.

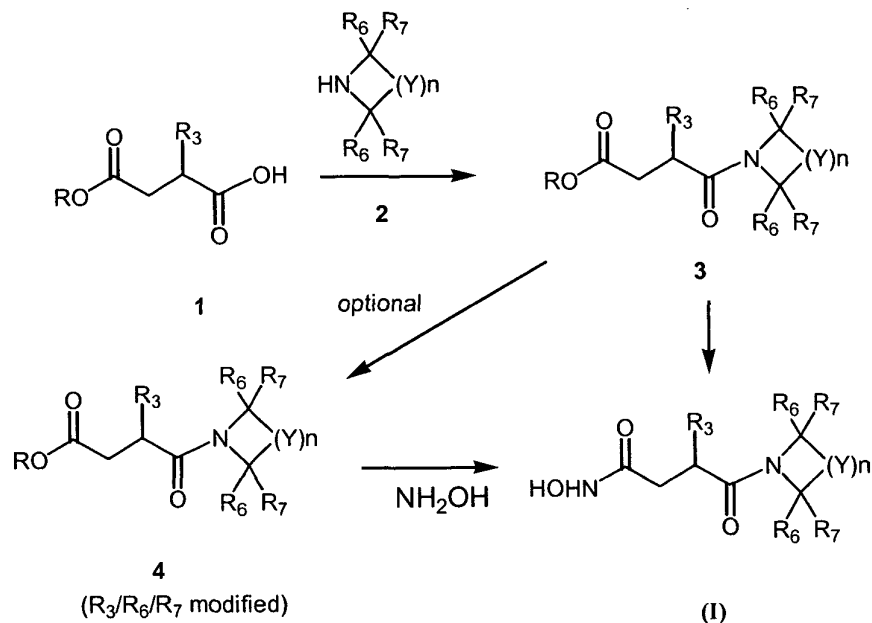
The starting materials and the intermediates of the reaction may be isolated and purified if desired using conventional techniques, including but not limited to filtration, distillation, crystallization, chromatography, and the like. Such materials may be characterized using conventional means, including physical constants and spectral data.

Preparation of compounds of Formula (I)

20 Compounds of Formula (I) can be prepared by methods well known in the art of organic chemistry. Representative synthetic procedures for preparing compounds of the present invention are illustrated and described in detail below. For example, compounds of Formula (I) can be prepared as described in Schemes A -D below.

A compound of Formula (I) where R₁, R₂, and R₄ are hydrogen, and R₃, R₆, R₇, Y, and n are as defined in the Summary of the Invention can be prepared as described in Scheme A below.

Scheme A



5

Treatment of a solution of a *mono*-protected succinate of formula 1 where R is an alkyl group such as methyl, ethyl, and the like, and R₃ is as defined in the Summary of the Invention, with an N,N-dialkylamine of formula 2, where R₆ and R₇ are as defined in the Summary of the Invention, provides a 3-aminocarbonyl-propionate derivative of formula 3. The reaction is typically carried out in the presence of an inert, polar aprotic solvent (e.g. DMF, dioxane, etc.) in the presence of a non-nucleophilic base (e.g. triethylamine, diisopropylethylamine, etc.) and a coupling reagent (e.g. EDCI, PyBOP, DIC, etc.). The reaction is initially started at low temperature, such as 0 °C, and then allowed to warm to room temperature, and then stirred for several hours. Some compounds of formula 1 are commercially available. Others can be prepared by methods well known in the art. For example *mono*-methyl succinate, *mono*-4-methyl-2-(*R*)-methylsuccinate is available commercially, while *mono*-4-methyl-2-(*R*)-butylsuccinate as described in detail in Example 16 below.

15

Amines of formula **2** are commercially available or they can be prepared by methods well known in the art. For example, *N, N*-dialkylamines such as pyrrolidine, piperidine, piperazine, morpholine, thiomorpholine, homopiperidine, homopiperazine, proline *tert*-butyl ester, *L*-proline-2-methylamide, (*S*)-(+)-2-(methoxymethyl)-pyrrolidine, *L*-proline-*N*-methoxy-*N*-methylamide, (*S*)-2-(pyrrolidinylmethyl)-pyrrolidine, *L*-proline-*N*-morpholineamide, *L*-proline-*N, N*-dimethylamide, homoproline methyl ester, *L*-homoproline *tert*-butylester, 3-(*R*)-*tert*-butoxy-*L*-proline-*O*-*t*-butyl ester, pipecolinic acid, 1,2,3,4-tetrahydroquinoline, 1-hydroxyethylpiperazine, 2-hydroxyethylpiperidine, 3-hydroxypiperidine, 4-hydroxypiperidine, 4-hydroxyproline, *L*-tetrahydroisoquinoline *tert*-butyl ester, 3-(*N*-Boc-amino)pyrrolidine, and *N*-Boc-*L*-prolinol are commercially available. Other *N, N*-dialkylamines **2** such as 2-acetylaminomethylpyrrolidine can be prepared from *N*-Boc-*L*-prolinol as described in Example 16 below. *trans*-3-Acetoxy-*L*-proline *O*-*tert*-butyl ester can be prepared from Cbz protected *trans*-3-hydroxy-*L*-proline as described in Example 17 below which can then be converted to *trans* 3-hydroxy-*L*-proline *O*-*tert*-butyl ester, if desired, by hydrolysis of the acetoxy group in *trans*-3-acetoxy-*L*-proline *O*-*tert*-butyl ester as described in Example 17 below.

Also, it will be recognized by a person skilled in the art that if compound **1** and/or **2** have additional reactive groups, then they must be suitably protected prior to carrying out the coupling reaction. Examples of suitable protecting groups and their introduction and removal are described in T.W. Greene and G. M. Wuts, "*Protecting Groups in Organic Synthesis*" Third Ed., Wiley, New York, 1999 and references cited therein. For example, if *R*₆ or *R*₇ is a carboxyl group or a hydroxy group then it can be protected as a *t*-butyl ester or benzyl ester or other suitable protecting group prior to the coupling reaction.

Compound **3** can optionally be converted to a compound of formula **4** where prior to converting it to a compound of Formula (I). This would be desirable if certain group(s) in compound **3**, e.g., *R*₃, *R*₆, and/or *R*₇ had to be transformed to other group(s) within the scope of the invention prior to introducing the hydroxamate group in the molecule. For example, a compound of formula **3** where *R*₆ or *R*₇ is a *tert*-butoxyamino group, can be converted to a corresponding compound of formula **4** where *R*₆ or *R*₇ is an acetylamino group by first treating **3** with an acid such as diluted

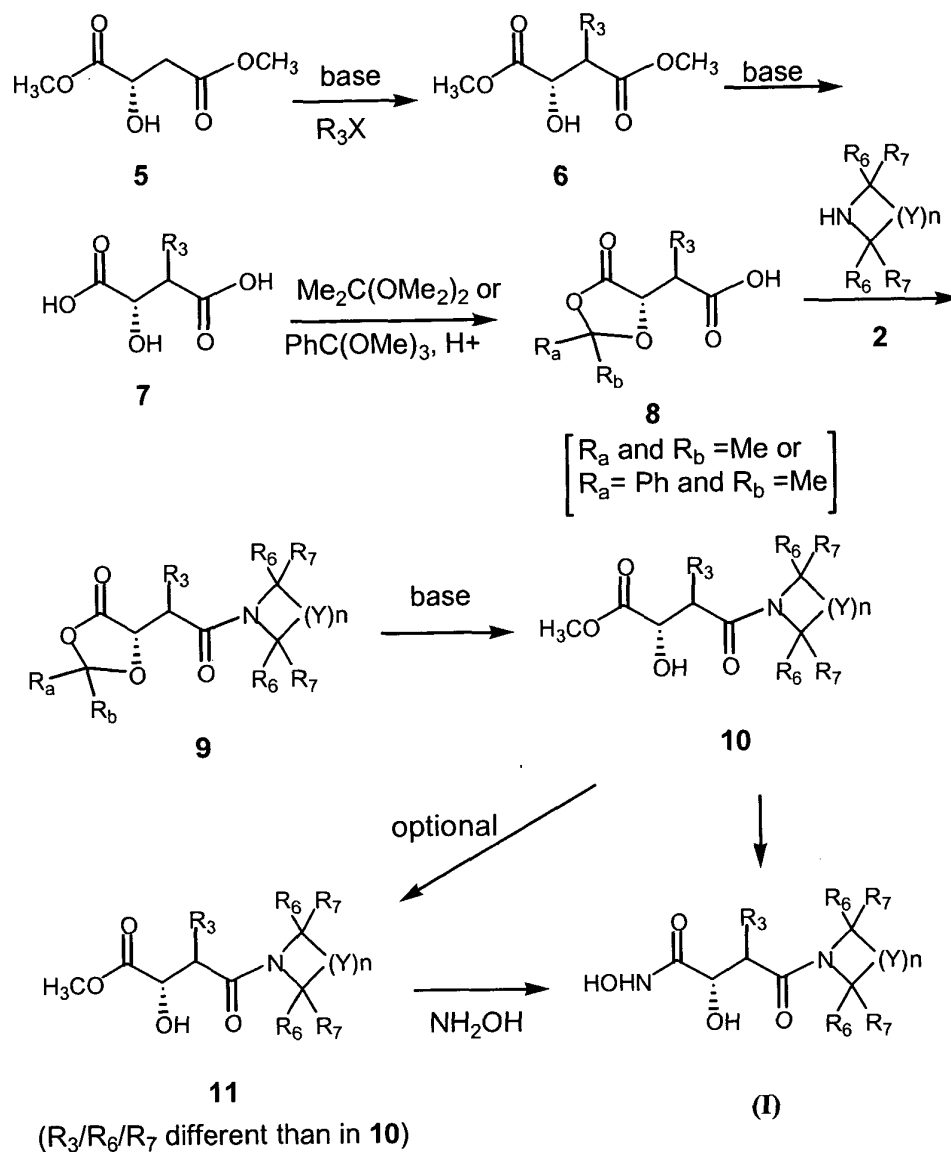
hydrochloric acid at ambient temperature to provide a corresponding compound of formula 3 where R_6 or R_7 is an amino group, followed by treatment with an acetylating agent such as acetic anhydride in the presence of an organic base such as pyridine.

5 A compound of formula 3 where R_6 and/or R_7 is a hydroxy can be converted to a compound of formula 4 where R_6 and/or R_7 is a sulfonamido group (i.e., -NHSO₂R₁₅ where R₁₅ is as defined in the Summary of the Invention) by first converting the hydroxy group into amino group, followed by treatment with a sulfonylating agent. A detailed description of this transformation is provided in
10 Example 34 below.

 A compound of formula 3 where R_6 and/or R_7 is a suitably protected carboxyl group can be converted to a compound of formula 4 where R_6 and/or R_7 is an aminocarbonyl group (i.e., -CONHR₁₄ or -CONR₁₄R₁₅ where R₁₄ and R₁₅ is as defined in the Summary of the Invention) by first deprotecting the carboxy group and
15 then treating with an amine of formula -NHR₁₄ or -NR₁₄R₁₅ (where R₁₄ and R₁₅ is as defined in the Summary of the Invention). Briefly, the reaction conditions for deprotecting of the carboxy group will depend on the nature of the protecting group. For example, if it is a benzyl ester, then treatment with hydrogen gas and an appropriate catalyst (e.g., 10 % palladium on carbon) will liberate the free carboxylic
20 acid. The amination reaction is typically carried out in the presence of an inert, polar aprotic solvent (e.g. DMF, dioxane, etc.) with a non-nucleophilic base (e.g. triethylamine, diisopropylethylamine, etc.) and a coupling reagent (e.g. EDCI, PyBOP, DIC, etc.). The reaction is initially started at low temperature, such as 0 °C, and then allowed to warm to room temperature, and then stirred for several hours.
25 Many amines of formulae NHR₁₄ and NR₁₄R₁₅ are available commercially, or can be readily prepared by methods well known in the art. For example, methylamine, aniline, 2-aminothiazole, etc., are commercially available. Others can be prepared, for example, *via* reductive amination of an aldehyde, or Fukuyama alkylation of a suitable nitroaryl sulfonamide followed by cleavage of the sulfonamide to liberate the
30 desired amine.

 Compound 3 or 4 is then converted to a hydroxamate compound of Formula (I) by treating it at 0 °C with aqueous 50 % hydroxylamine in a polar organic solvent

Scheme B



- 5 Treatment of dimethyl malate **5** under strongly basic conditions with an appropriate alkylhalide R_3X (where R_3 is alkyl, alkenyl, alkynyl, substituted, heteroalkyl and X is halo such as chloro, bromo, or iodo) provides 2-substituted dimethyl malate **6**. The reaction is typically carried out in a polar aprotic solvent such

as THF, and the base is typically lithium diisopropylamide (LDA). The reaction is initially carried out at a low temperature, preferably at about -78°C , and then allowed to slowly warm to room temperature. The reaction is then stirred for several hours. The reaction is typically higher yielding when R_3X is an allylic halide. After the alkylation is complete the resulting olefin can be reduced, if desired, to provide a compound of formula **6** where R_3 is alkyl. The typically reduction procedure involves a suspension of **6** and a catalyst (e.g., 10 % palladium on carbon) in a solvent such as ethylacetate and would be stirred under a hydrogen atmosphere for several hours to afford the corresponding compound of formula **6** where R_3 is alkyl. Many compounds of formula R_3X are commercially available or they can be prepared by methods well known in the art. For example, iodomethane, benzylbromide, crotylbromide, allylbromide, vinylbromide are commercially available. Others can be prepared from the corresponding alcohol by first activating the hydroxy group as a *p*-toluenesulfonate ester (tosyl ester), followed by tosylate displaced with a halide ion in a modified Finkelstein procedure to afford an alkylhalide as described in working examples below.

Treatment of **6** with a base affords a malic acid derivative of formula **7**. The base can be an inorganic base such as lithium hydroxide or potassium hydroxide, and is most preferably sodium hydroxide. This reaction is usually performed in a polar, protic solvent such as methanol. Treatment of **7** with an orthoacetate, such as trimethylorthobenzoate, in the presence of an acidic catalyst affords an orthoester **8** (R_a is $-\text{Ph}$ and R_b is $-\text{OMe}$). This reaction is ideally performed with a co-solvent, preferably in a mixture of toluene. The reaction is ideally performed at a higher temperature, most preferably at 110°C . The catalyst is typically a sulfonic acid, such as *p*-toluenesulfonic acid, or most preferably camphorsulfonic acid.

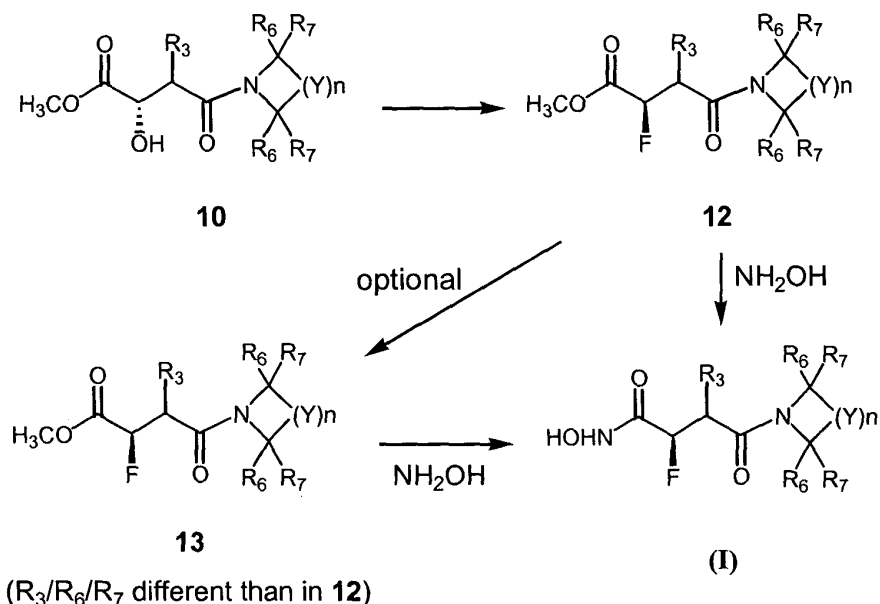
Alternatively, treatment of **7** with 2,2-dimethoxypropane in the presence of *p*-toluenesulfonic acid provides an acetonide of formula **8** where R_a and R_b are methyl.

Treatment of the orthoester or acetonide **8** with a dialkylamine of formula **2** under the reaction conditions described in Scheme A provides a compound of formula **9** which upon treatment with a base, preferably the salt of an alcohol, and more preferably sodium methoxide in an alcoholic solvent then provides a 2-hydroxy-3-aminocarbonyl-propionate derivative of formula **10**.

Compound **10** is then optionally converted to a compound of formula **11** for reasons discussed in Scheme A such as derivatizing the R₃, R₆ and/or R₇ groups prior to converting it to a compound of Formula (I). Alternatively, compound **10** it can be directly converted to a compound of Formula (I) as described in Scheme A above.

5 It will be recognized by a person skilled in the art that the hydroxy group in compound **10** can be replaced by various other R₁ groups as defined in the Summary of the Invention prior to converting it to a compound of Formula (I). Some representative examples are discussed below:

10 (i) the hydroxy group in compound **10** can be replaced by a fluoro group prior to converting it to a compound of Formula (I) as shown below.



15 The hydroxyl group at the C2 carbon in compound **10** can be replaced by a fluoro group by first converting the hydroxyl group into an active ester followed by displaced with fluorine to afford compound **12**. The reaction is performed in a halogenated solvent, such as dichloromethane (DCM), in the presence of an organic base, such as pyridine. The alcohol is typically activated as a sulfonate ester, preferably the trifluoromethane-sulfonate. This esterification reaction is typically carried out at a low temperature, preferably about -20 °C. The active ester is then

reacted with a fluoride ion, typically derived from tris(dimethylamino)sulfur-(trimethylsilyl)difluoride (TAS-F). This reaction is also carried out at a low temperature, preferably at about -50 °C, and then slowly allowed to warm to ambient temperature. Compound **12** is then converted to a compound of Formula (I) either directly or through compound **13** as described above. A detailed description of this procedure is provided in Example 6 below. It will be noted that the stereochemistry at the C2 carbon atom is inverted during this transformation.

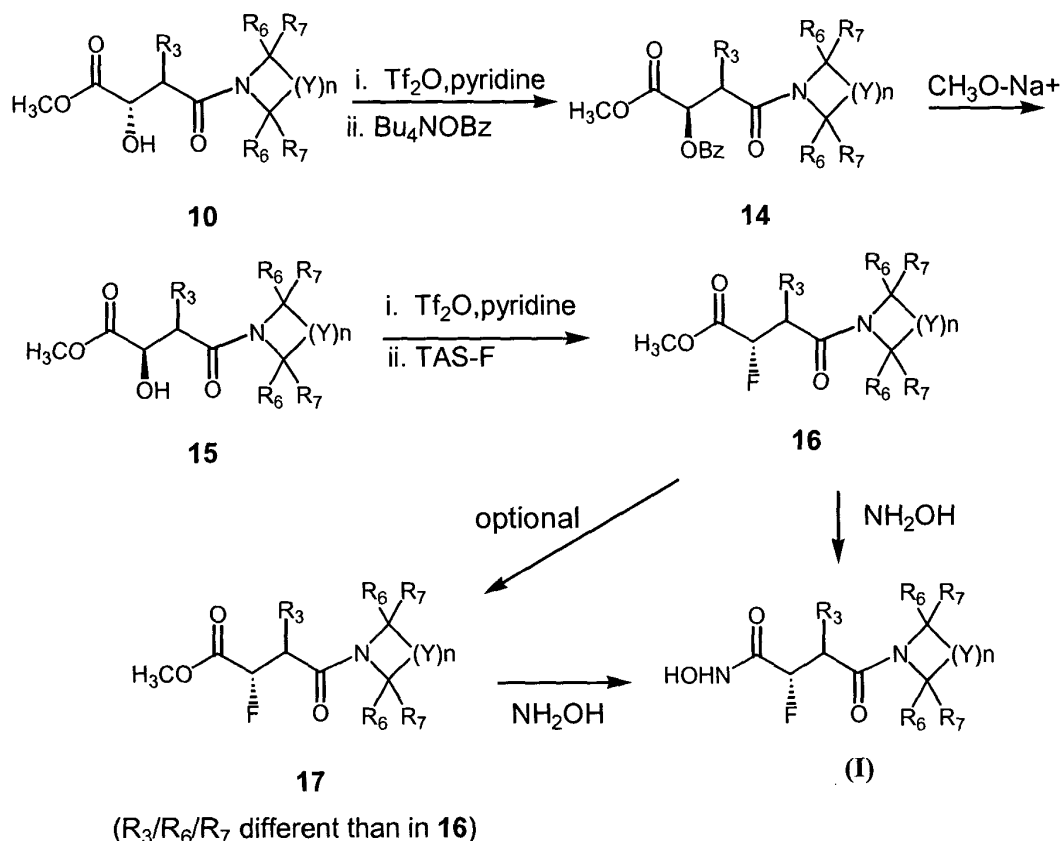
(ii) the hydroxy group in compound **10** can be converted to an alkoxy under alkylation reaction conditions such as treatment of **10** with an alkyl halide such as methyl iodide, ethyl iodide, benzyl bromide, and the like, in the presence of a strong base such as sodium hydride and in a polar solvent such as dimethylformamide. Detailed description of this procedure is provided in Example 45 below.

(iii) the hydroxy group in compound **10** can be converted to benzyloxy group by first converting it into an activated ester such as a sulfonate ester, preferably the trifluoromethanesulfonate, followed by treatment with tetrabutyl ammonium benzoate. Detailed description of this procedure is provided in Example 47 below.

(iii) the hydroxy group in compound **10** can be converted to thiol group by first converting it into an activated ester such as a sulfonate ester, preferably the trifluoromethanesulfonate, followed by treatment potassium thioacetate. Detailed description of this procedure is provided in Example 48 below.

(iv) the hydroxy group in compound **10** can be converted to an azido or amino group or it's derivatives by first converting it into an activated ester such as a sulfonate ester, preferably the trifluoromethanesulfonate, followed by treatment with sodium azide. The azide group can optionally reduced under catalytic hydrogenation reaction conditions to give an amino group which can be further derivatized by methods well known in the art. Detailed description of this procedure is provided in Example 49 and 34 below.

(vi) the maintainence of the stereochemistry at the carbon atom carrying the hydroxy group in compound **10**, the C2 carbon, can be achieved by carrying out double inversion as illustrated and described below.



The hydroxyl at the C-2 carbon of intermediate **10** is converted to an active ester as described above in (i) above. Nucleophilic substitution with a variety of nucleophiles such as acetate anion, or more preferably, tetrabutylammonium benzoate, provides intermediate **14**. This reaction proceeds in a hydrocarbon solvent, preferably in toluene. One skilled in the art will understand that the above nucleophilic displacement reaction results in an inversion of stereochemistry at the C-2 position.

Compound **14** is treated with a base to afford hydroxy derivative **15**. This base is preferably the salt of an alcohol such as sodium methoxide, sodium ethoxide and the like, and more preferably sodium methoxide. The reaction proceeds in an alcoholic solvent such as methanol, ethanol and the like, most preferably in methanol.

Compound **15** is re-activated as a sulfonate ester, preferably a trifluoromethane sulfonate as described above and then treated with a fluorination

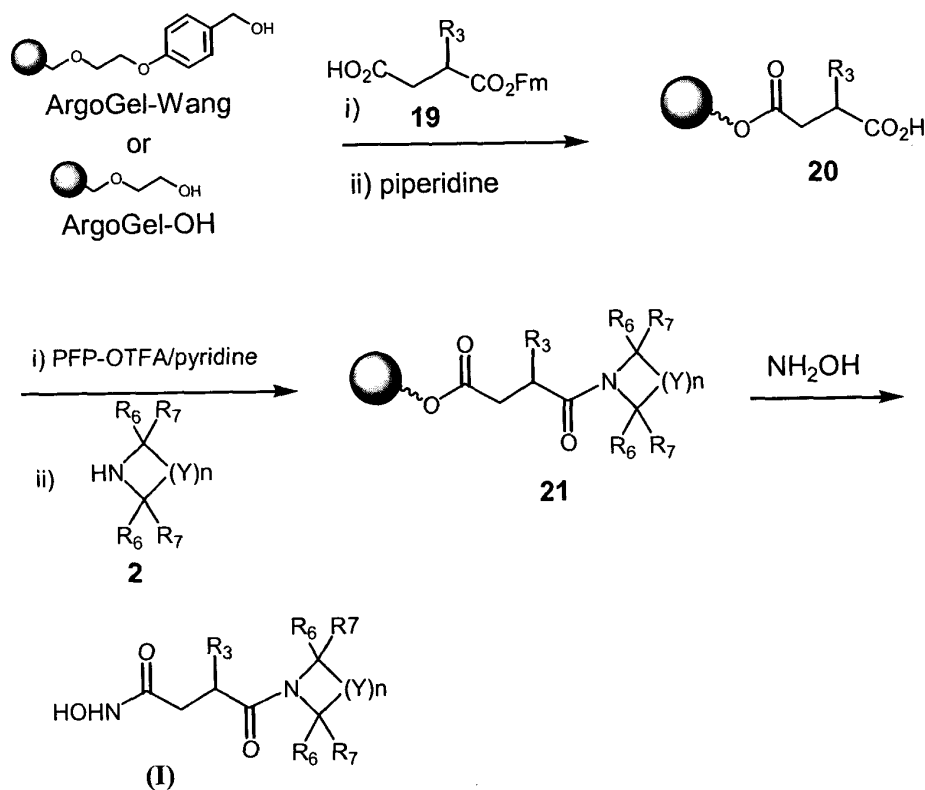
reagent, preferably TAS-F, to afford the corresponding fluoro intermediate **16** which has the same stereochemistry at the C-2 carbon as in intermediate **10**.

Compound **16** or **17** is then converted to a compound of Formula (I) as discussed above.

5

A compound of Formula (I) can also be prepared as illustrated in Scheme C below.

Scheme C

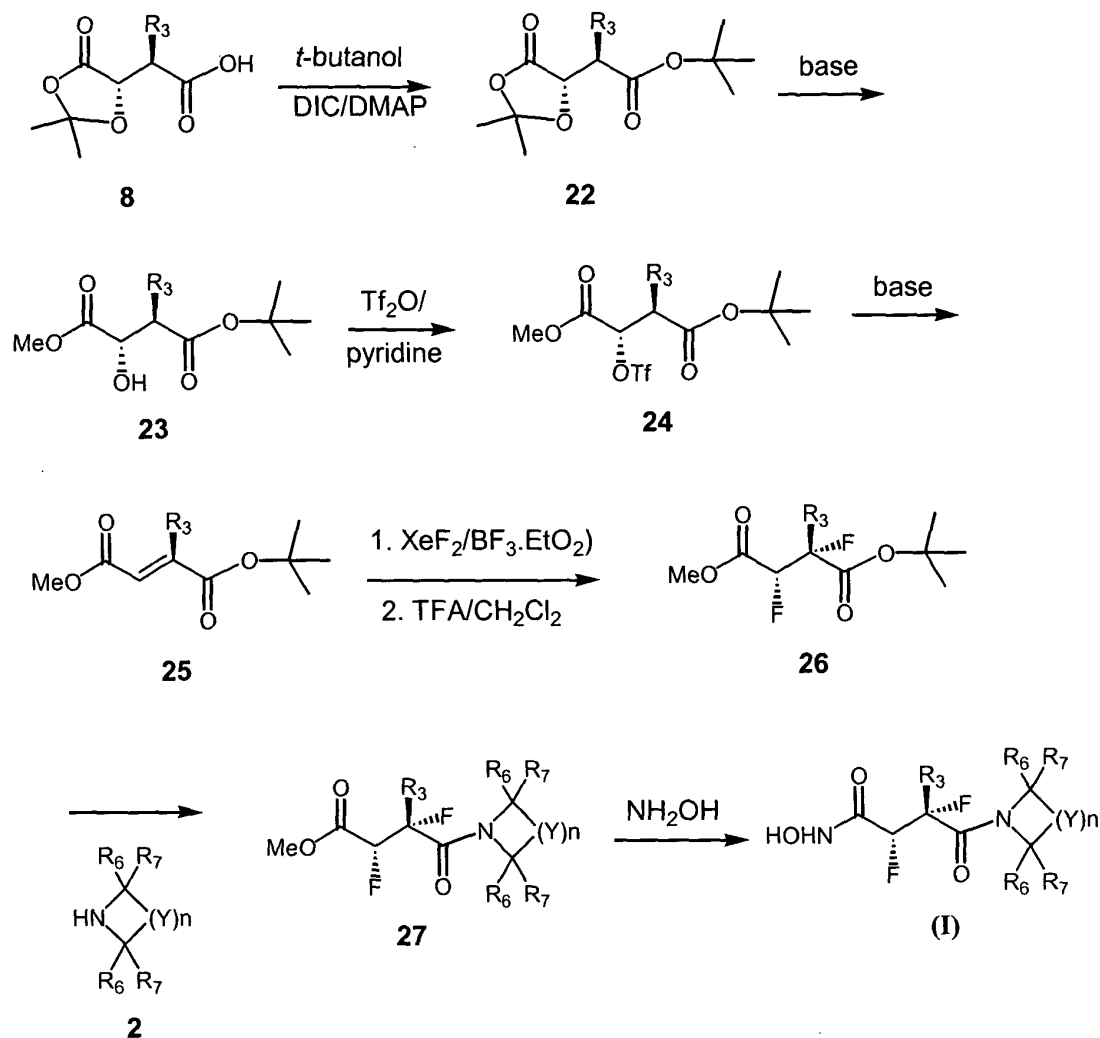


10

Treatment of a suspension of ArgoGel-Wang or ArgoGel-OH resin with an Fmoc-protected succinic acid of formula **19** (wherein R_3 is as defined in the Summary of the Invention) in the presence of a coupling agent such as di-isopropylazodicarboxylate and triphenylphosphine, followed by treatment with piperidine provides a resin bound Fmoc-protected succinic acid **20**. The coupling reaction is carried out in a

15

Scheme D



- Treatment of a compound of formula 8 with an alcohol such as *tert*-butanol in the presence of a suitable coupling agent such as DIC and a base such as DMAP provides the corresponding *tert*-butyl ester of formula 22. Treatment of 22 with a base such as sodium methoxide in methanol provides 2-hydroxysuccinate derivative of formula 23. Compound 23 is then converted to a trifluoromethanesulfonate ester derivative 24 using triflic anhydride in the presence of a base such as triethylamine, pyridine and the like. Treatment of 24 with a base such as triethylamine provides a maleic acid derivative of formula 25 which upon reaction with xenon difluoride in the

presence of boron trifluoride etherate provides a 2,3-difluorosuccinate derivative. Removal of the tert-butyl group with trifluoroacetic acid provides the corresponding succinic acid derivative 26 which is then converted to a compound of Formula (I) as described above.

5

Administration, Utility and Testing

Administration and Pharmaceutical Composition

The present invention also provides pharmaceutical compositions which comprise a bioactive hydroxamic acid compound or derivative, or a pharmaceutically acceptable salt thereof, and a pharmaceutically acceptable carrier. The compositions of the invention include those in a form adapted for oral, topical or parenteral use and can be used for the treatment of bacterial infection in animals, preferably mammals, more preferably humans.

The antibiotic compounds, also referred to herein as antimicrobial compounds, according to the invention can be formulated for administration in any convenient way for use in human or veterinary medicine, by analogy with other antibiotics. Such methods are known in the art (*see, e.g., Remington's Pharmaceutical Sciences*, Easton, PA: Mack Publishing Co.) and are not described in detail herein.

The composition can be formulated for administration by any route known in the art, such as subdermal, inhalation, oral, topical or parenteral. The compositions can be in any form known in the art, including but not limited to tablets, capsules, powders, granules, lozenges, creams or liquid preparations, such as oral or sterile parenteral solutions or suspensions. The compounds can also be administered in liposome formulations. The compounds can also be administered as prodrugs, where the prodrug administered undergoes biotransformation in the treated mammal to a form which is biologically active.

The topical formulations of the present invention can be presented as, for instance, ointments, creams or lotions, solutions, salves, emulsions, plasters, eye ointments and eye or ear drops, impregnated dressings and aerosols, and can contain appropriate conventional additives such as preservatives, solvents to assist drug penetration and emollients in ointments and creams.

The formulations can also contain compatible conventional carriers, such as cream or ointment bases and ethanol or oleyl alcohol for lotions. Such carriers can be present, for example, from about 1% up to about 99% of the formulation. For example, they can form up to about 80% of the formulation.

5 Tablets and capsules for oral administration can be in unit dose presentation form, and can contain conventional excipients such as binding agents, for example syrup, acacia, gelatin, sorbitol, tragacanth, or polyvinylpyrrolidone; fillers, for example lactose, sugar, maize-starch, calcium phosphate, sorbitol or glycine; 10 tableting lubricants, for example magnesium stearate, talc, polyethylene glycol or silica; disintegrants, for example potato starch; or acceptable wetting agents such as sodium lauryl sulphate. The tablets can be coated according to methods well known in standard pharmaceutical practice.

 Oral liquid preparations can be in the form of, for example, aqueous or oily suspensions, solutions, emulsions, syrups or elixirs, or can be presented as a dry 15 product for reconstitution with water or another suitable vehicle before use. Such liquid preparations can contain conventional additives, such as suspending agents, for example sorbitol, methyl cellulose, glucose syrup, gelatin, hydroxyethyl cellulose, carboxymethyl cellulose, aluminium stearate gel or hydrogenated edible fats; emulsifying agents, for example lecithin, sorbitan monooleate, or acacia; non-aqueous 20 vehicles (which can include edible oils), for example almond oil, oily esters such as glycerine, propylene glycol, or ethyl alcohol; preservatives, for example methyl or propyl p-hydroxybenzoate or sorbic acid, and, if desired, conventional flavoring or coloring agents.

 For parenteral administration, fluid unit dosage forms are prepared utilizing 25 the compound and a sterile vehicle, water being preferred. The compound, depending on the vehicle and concentration used, can be either suspended or dissolved in the vehicle or other suitable solvent. In preparing solutions, the compound can be dissolved in water for injection and filter sterilized before filling into a suitable vial or ampoule and sealing. Advantageously, agents such as a local anesthetic preservative 30 and buffering agents can be dissolved in the vehicle. To enhance the stability, the composition can be frozen after filling into the vial and the water removed under vacuum. The dry lyophilized powder is then sealed in the vial and an accompanying

vial of water for injection can be supplied to reconstitute the liquid prior to use. Parenteral suspensions are prepared in substantially the same manner except that the compound is suspended in the vehicle instead of being dissolved and sterilization cannot be accomplished by filtration. The compound can be sterilized by exposure to ethylene oxide before suspending in the sterile vehicle. Advantageously, a surfactant or wetting agent is included in the composition to facilitate uniform distribution of the compound.

The compositions can contain, for example, from about 0.1% by weight to about 99% by weight, e.g., from about 10-60% by weight, of the active material, depending on the method of administration. Where the compositions comprise dosage units, each unit will contain, for example, from about 1-500 mg of the active ingredient. The dosage as employed for adult human treatment will range, for example, from about 1 to 3000 mg per day, for instance 1500 mg per day depending on the route and frequency of administration. Such a dosage corresponds to about 0.015 to 50 mg/kg per day. Suitably the dosage is, for example, from about 5 to 20 mg/kg per day.

Utility

The hydroxamate compounds of the present invention can be used for the treatment or prevention of infectious disorders caused by a variety of bacterial or prokaryotic organisms. Examples include Gram positive and Gram negative aerobic and anaerobic bacteria, including *Staphylococci*, for example *S. aureus* and *S. epidermidis*; *Enterococci*, for example *E. faecalis* and *E. faecium*; *Streptococci*, for example *S. pneumoniae*; *Haemophilus*, for example *H. influenza*; *Moraxella*, for example *M. catarrhalis*; and *Escherichia*, for example *E. coli*. Other examples include *Mycobacteria*, for example *M. tuberculosis*; intercellular microbes, for example *Chlamydia* and *Rickettsiae*; and *Mycoplasma*, for example *M. pneumoniae*.

In one embodiment, compositions, for treating or preventing infectious disorders are provided, comprising a hydroxamic acid compound or derivative as disclosed herein in combination with a pharmaceutically acceptable carrier.

In another embodiment, there is provided a dosage amount of a hydroxamic acid compound or derivative as disclosed herein in an effective amount for the

treatment, prevention or alleviation of a disorder, such as an infectious disorder. Hydroxamic acid compounds or derivatives can be screened for activity against different microbial agents and appropriate dosages can be determined using methods available in the art.

5 The compounds can be used to treat a subject to treat, prevent, or reduce the severity of an infection. Subjects include animals, plants, blood products, cultures and surfaces such as those of medical or research equipment, such as glass, needles, surgical equipment and tubing, and objects intended for temporary or permanent implantation into an organism. Treating a subject includes, but is not limited to, preventing, reducing, or eliminating the clinical symptoms caused by an infection of a subject by a microorganism; preventing, reducing, or eliminating an infection of a subject by a microorganism; or preventing, reducing, or eliminating contamination of a subject by a microorganism. The microorganism involved is preferably a prokaryote, more preferably a bacterium.

15 In one embodiment, methods of treating or preventing an infectious disorder in a subject, such as a human or other animal subject, are provided, by administering an effective amount of a hydroxamic acid compound or derivative as disclosed herein to the subject. In one embodiment, the compound is administered in a pharmaceutically acceptable form optionally in a pharmaceutically acceptable carrier. As used herein, an "infectious disorder" is any disorder characterized by the presence of a microbial infection, such as the presence of bacteria. Such infectious disorders include, for example central nervous system infections, external ear infections, infections of the middle ear, such as acute otitis media, infections of the cranial sinuses, eye infections, infections of the oral cavity, such as infections of the teeth, gums and mucosa, upper respiratory tract infections, lower respiratory tract infections, genitourinary infections, gastrointestinal infections, gynecological infections, septicemia, bone and joint infections, skin and skin structure infections, bacterial endocarditis, burns, antibacterial prophylaxis of surgery, and antibacterial prophylaxis in immunosuppressed patients, such as patients receiving cancer chemotherapy, or organ transplant patients. The compounds and compositions comprising the compounds can be administered by routes such as topically, locally or systemically. Systemic application includes any method of introducing the compound into the tissues of the

body, *e.g.*, intrathecal, epidural, intramuscular, transdermal, intravenous, intraperitoneal, subcutaneous, sublingual, nasal, vaginal, rectal, and oral administration. The specific dosage of antimicrobial to be administered, as well as the duration of treatment, can be adjusted as needed.

5 Additionally, the compounds of this invention can also be used to prepare a composition in an inert diluent which is useful in inhibiting bacterial growth. An "inert diluent" means an excipient that is useful in preparing a composition that is generally safe, non-toxic and neither biologically nor otherwise undesirable.

10 Representative pharmaceutical formulations containing a compound of Formula (I) are described below.

Testing

15 The ability of the compounds of this invention to inhibit peptide deformylase was measured by *in vitro* assay described in detail in Biological Example below. The antimicrobial activity of the compounds of this invention was tested as described in detail in Biological Example 2 below. The selective inhibition of PDF compared to MMP-7 (Matrilysin) by the compounds of this invention was tested as described in detail in Biological Example 3 below.

EXAMPLES

20 The following preparations and examples are given to enable those skilled in the art to more clearly understand and to practice the present invention. They should not be considered as limiting the scope of the invention, but merely as being illustrative and representative thereof.

Abbreviations

The following abbreviations are used:

25 AcOH, HOAc = acetic acid
 Ac₂O = acetic anhydride
 BOC, Boc = *t*-butyloxycarbonyl
 DCC = dicyclohexylcarbodiimide
 DCM = dichloromethane
30 DIC = diisopropylcarbodiimide
 DIAD = diisopropylazodicarboxylate

- DIEA = diisopropylethylamine
 DMF = dimethylformamide
 EDC = N-(3-Dimethylaminopropyl)-N'-ethylcarbodiimide
 Et = ethyl
- 5 EtOAc = ethyl acetate
 Fmoc, Fmoc = 9-fluorenylmethyloxycarbonyl
 HATU = O-(7-aza-benzotriazol-1-yl)-N,N,N',N'-tetramethyluronium hexafluorophosphate
 HBTU = O-(benzotriazol-1-yl)-N,N,N',N'-tetramethyluronium hexafluorophosphate
- 10 HHMPA = (4-hydroxymethyl-3-methoxyphenoxy)-alkanoic acid
 HMP resin = hydroxymethylphenoxy resin
 HOAt = 1-hydroxy-7-azabenzotriazole
 HOBt = 1-hydroxybenzotriazole
 Me = methyl
- 15 Mem = methoxy ethoxy methyl ether
 MeOH = methanol
 MMP = matrix metalloproteinase
 Mom = methoxy methyl ether
 NMM = N-methyl morpholine
- 20 NPEOC = 4-nitrophenethyloxycarbonyl
 NPEOM = 4-nitrophenethylmethyloxycarbonyl
 NVOC = 6-nitroveratryloxycarbonyl
 NVOM = nitroveratryloxymethyl ether
 PEG-PS resins or PS-PEG resin = polyethylene glycol-polystyrene graft copolymer
- 25 resins
 PFP-OTFA = pentafluorophenyl trifluoroacetate
 PyBOP = benzotriazole-1-yl-oxy-tris-pyrrolidinophosphonium hexafluorophosphate
 PyBROP = bromotripyrrolidinophosphonium hexafluorophosphate
 RT = room temperature
- 30 TBP = tributylphosphate
 TBS, TBDMS = t-butyldimethylsilyl
 tBu = t-butyl

TES = triethylsilane

TFA = trifluoroacetic acid

TGS resin = TENTAGEL S resin

TGS NH₂ resin = TENTAGEL S NH₂ resin

5 THF = tetrahydrofuran

THP = 2-tetrahydropyranyl

TMAD = N,N,N',N'-tetramethylazodicarboxamide (1,1'-Azobis(N,N-dimethylformamide))

TMOF = trimethylorthoformate

10 TPP = triphenyl phosphine

TsCl = tosyl chloride

TsOH = toluenesulfonic acid

Trt = trityl

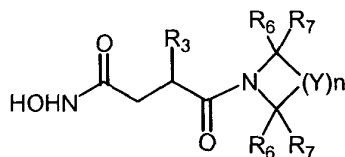
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SYNTHETIC EXAMPLES

GENERAL PROCEDURE A

Synthesis of N-hydroxy-3-aminocarbonylpropionamide
(following Scheme A)

20



Step 1

To a solution of mono-protected succinate *e.g.*, *mono-4-methyl 2-(R)-butylsuccinic acid 1* (1 mmol) in DMF was added dialkylamine **2** (1 mmol), DIEA (0.4 mL, 2.3 mmol), and an activating reagent (*e.g.* EDC, PyBOP, DIC, DCC, etc.; 1 mmol). The mixture was stirred overnight, then diluted with ethyl acetate and washed with aqueous HCl (1 N), water, saturated sodium bicarbonate, brine, and then dried (Na₂SO₄). The filtrate was concentrated and then purified on silica gel (Merck 60; ethyl acetate/hexane) to afford 3-aminocarbonylpropionate **3**.

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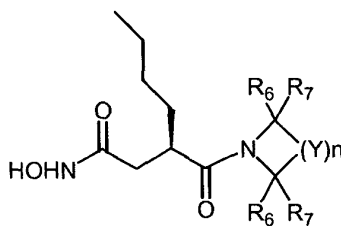
Step 2

3-Aminocarbonylpropionate **3** (0.1 mmol) was treated with dioxane (1 mL) and hydroxylamine (50% in water, 2 mL) for 1 to 3 days, and then can be purified by preparative reverse-phase (C18) HPLC to afford the desired N-hydroxy-3-aminocarbonylpropionamide.

GENERAL PROCEDURE B

Synthesis of N-hydroxy-3-(*R*)-*n*-butyl-3-aminocarbonylpropionamide—

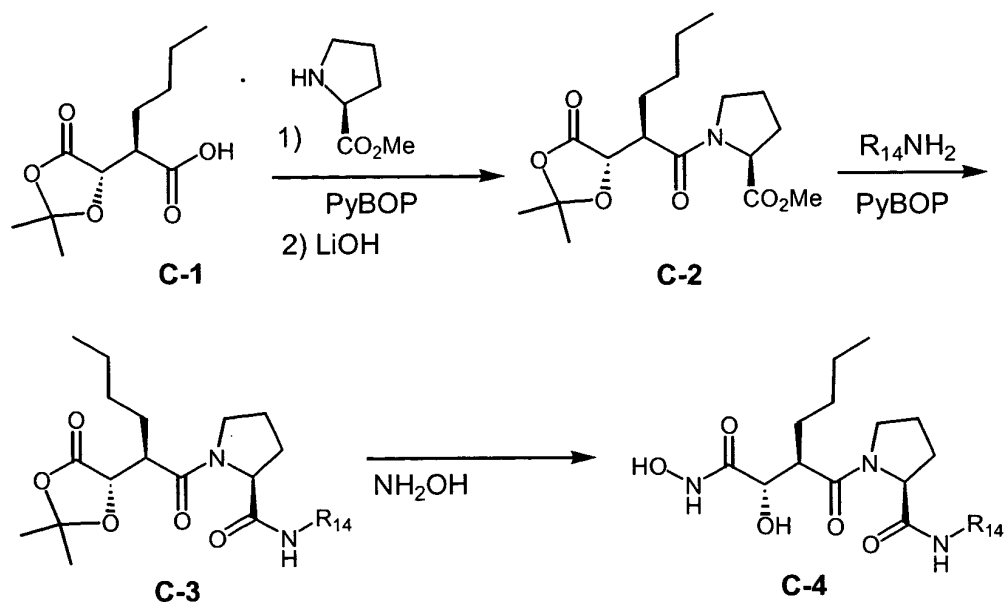
Alternate method



To *mono*-4-methyl 2-(*R*)-butylsuccinic acid (0.2 mmol) in dioxane (1 mL) was added amine **2** (0.2 mmol), DIEA (0.4 mmol) and an activating reagent (e.g. EDC, PyBOP, DIC, DCC, etc.; 0.2 mmol); and the mixture was stirred for 2 h. Aqueous 50% hydroxylamine was added (1.5 mL) and the mixture was stirred an additional 1-2 days. The reaction mixture can then be purified by preparative reverse-phase (C18) HPLC to afford N-hydroxy-3-(*R*)-*n*-butyl-3-aminocarbonylpropionamide.

GENERAL PROCEDURE C

Synthesis of N-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide



Step 1

To 2-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)hexanoic acid **C-1** (prepared in four steps from dimethyl malate; see Example 21 for details) in DMF was added

5 proline O-methyl ester, DIEA and HATU and the solution stirred 4 hours. Standard aqueous workup afforded the desired amide, which was dissolved in methanol and treated with lithium hydroxide to yield 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(S)-carboxypyrrolidin-1-ylcarbonyl)pentane **C-2**.

10 Step 2

To 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(S)-carboxypyrrolidin-1-ylcarbonyl)pentane **C-2** in DMF was added an amine $R_{14}NH_2$, DIEA and HATU and the solution stirred for 2 h. Aqueous workup followed by silica gel chromatography afforded 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(S)-aminocarbonylpyrrolidin-

15 1-ylcarbonyl)pentane **C-3**.

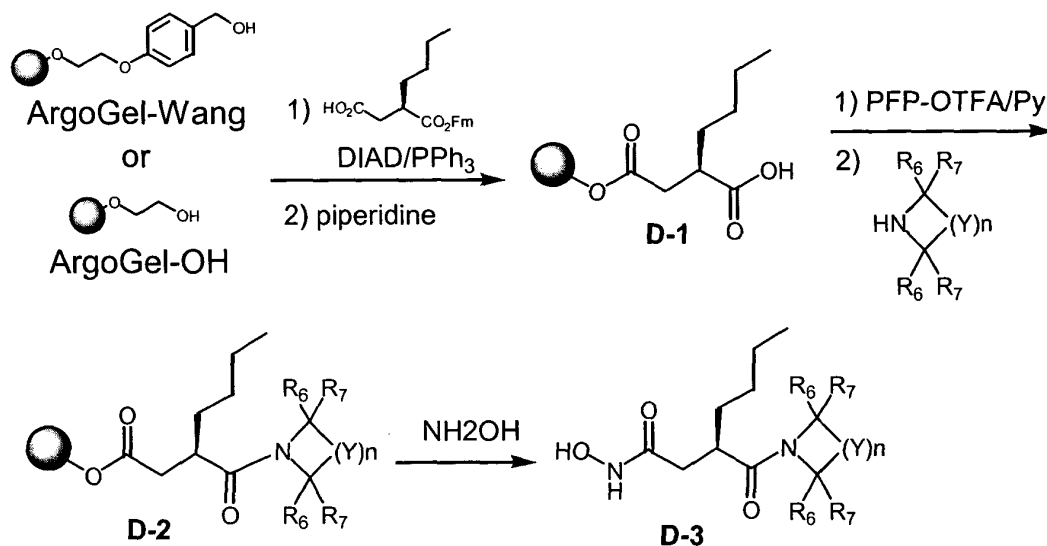
Step 3

To 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(S)-aminocarbonylpyrrolidin-1-ylcarbonyl)pentane **C-3** in dioxane was treated with 50 % aqueous hydroxylamine for 4 h. The reaction mixture was then purified by preparative

reverse-phase (C18) HPLC to afford N-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide **C-4**.

GENERAL PROCEDURE D

- 5 Synthesis of N-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-ylcarbonyl]propionamide
(following Scheme C)



10 Step 1

To ArgoGel resin (20 g) solvated in DCM was added 2-(*R*)-*n*-butylsuccinate 1-(9-fluorenyl) ester (10.0 g, 23.2 mmol), diisopropylazodicarboxylate (DIAD; 4.8 mL, 24.3 mmol) and triphenylphosphine (PPh₃, 6.38 g, 24.3 mmol); the reaction mixture was shaken for 6 h. The resin is filtered and was washed with DCM (3x), MeOH (3 x) and DMF (3 x). A solution of piperidine (40 mL, 10% in DMF) was added and the resin mixture is shaken for 3 h. The resin was filtered and then washed sequentially with DMF (3x), DCM (2x), MeOH (2x) and DMF (3x) to afford intermediate **D-1**.

Step 2

- 20 To resin **D-1** in DMF was added PFP-OTFA and pyridine and the mixture was shaken for 4 h. The resin was filtered and washed with DMF (3x), MeOH (2x), DCM

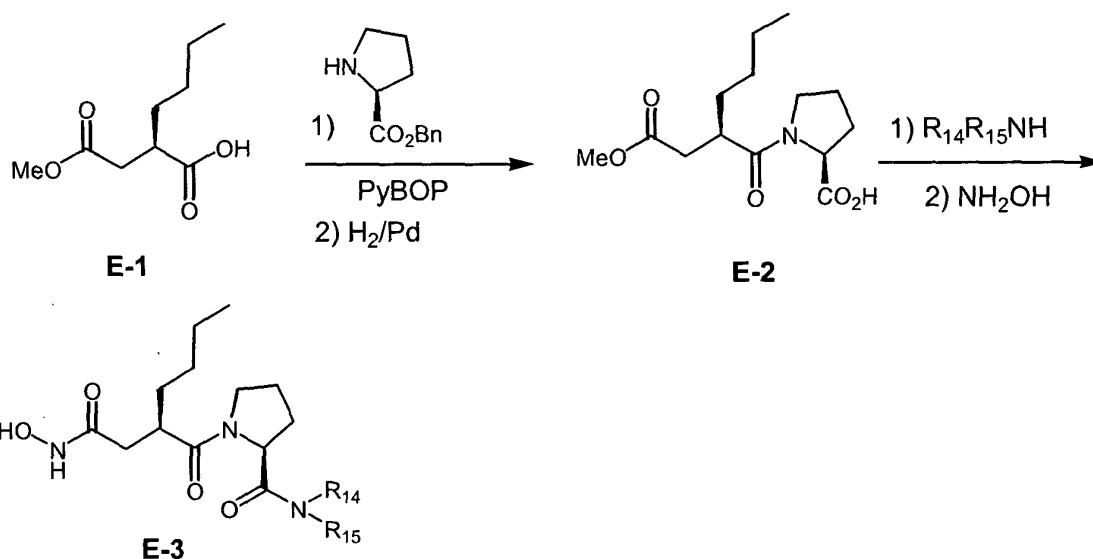
(2x), and ether (2x) and dried under vacuum. To a portion of the resin was added a solution of an amine (1 mmol) and DIEA (1.5 mmol) in DMF (1 mL). The resin was shaken overnight, filtered and washed with DMF, MeOH, and DCM to afford **D-2**.

Step 3

- 5 To **D-2** was added dioxane (0.5 mL) and aqueous 50% hydroxylamine (1 mL). After 18 h, the cleavage products were drained and then purified by preparative reverse-phase (C18) HPLC to afford the desired hydroxamate **D-3**.

GENERAL PROCEDURE E

- 10 Synthesis of N-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]propionamide



Step 1

- 15 To a solution of *mono*-4-methyl 2-(*R*)-butylsuccinic acid, (prepared in three steps from hexanoylchloride and *t*-butyl bromoacetate as described below; 1 mmol) in DMF was added proline O-benzyl ester (1 mmol), DIEA (0.4 mL, 2.3 mmol), and a coupling reagent (e.g. EDCI, PyBOP, DIC, etc.; 1 mmol). The mixture was stirred overnight, then diluted with ethyl acetate and washed with aqueous HCl (1 N), water, 20 saturated sodium bicarbonate, brine, and then dried (Na₂SO₄). The filtrate was

concentrated and then purified on silica gel (Merck 60; ethyl acetate/hexane) to afford methyl-3-(*R*)-butyl-3-(2-(*S*)-benzyloxycarbonylpyrrolidin-1-ylcarbonyl)propionate.

To this amide (0.1 mmol) in ethylacetate (10 mL) was added 10 % Pd/C (100 mg) and the solution stirred under a hydrogen atmosphere for 8 h. The suspension was filtered

5 through a Celite plug and then concentrated to afford methyl-3-(*R*)-butyl-3-(2-(*S*)-carboxypyrrolidin-1-ylcarbonyl)propionate **E-2**.

Step 2

To methyl-3-(*R*)-butyl-3-(2-(*S*)-carboxycarbonylpyrrolidin-1-ylcarbonyl)-propionate **E-2** (100 mg) in DMF (1 mL) was added an amine (1 equivalent), DIEA

10 (2.5 equivalents) and HATU (1 equivalent) and the reaction stirred for 4 h. The solution was then cooled to 0 °C, 50 % aqueous hydroxylamine was added (400 µL), and the reaction stirred at 4 °C for 4 hours to 3 days, depending upon the succinate.

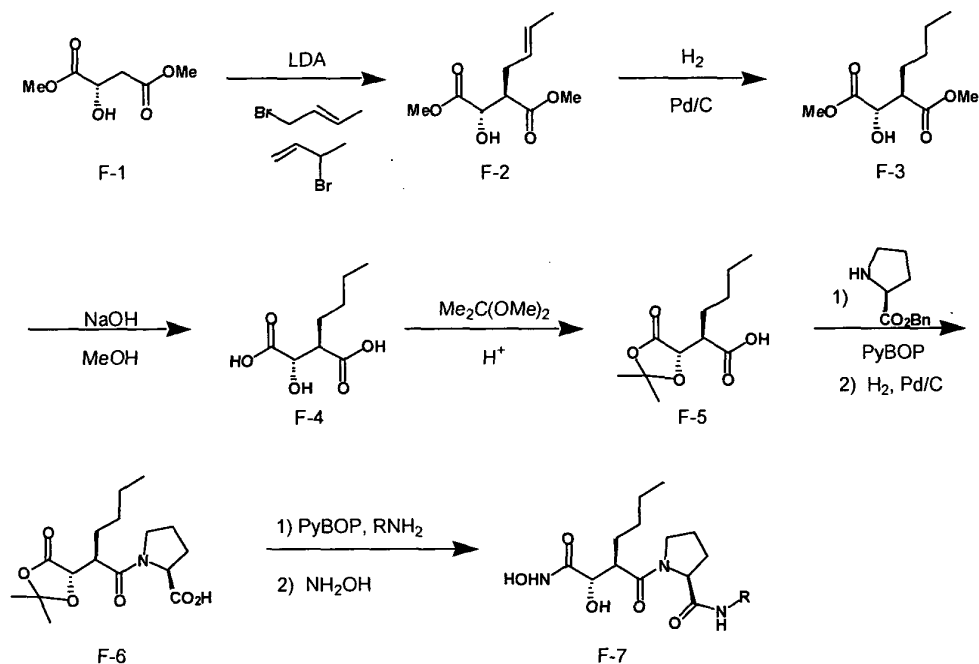
The crude reaction mixture was then purified by preparative reverse-phase (C18)

15 HPLC to afford the desired compound methyl-3-(*R*)-butyl-3-(2-(*S*)-amino-carbonylpyrrolidin-1-ylcarbonyl)propionate **E-3**.

GENERAL PROCEDURE F

Synthesis of N-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-hydroxypropionamide

20



Step 1

To a solution of diisopropylamine (14 mL, 100 mmol) in THF at 0 °C was added *n*-butyllithium (2.5 M in hexane, 40 mL, 100 mmol) over 10 min. The mixture was stirred at RT for 30 min., and then added *via* cannula to a -78 °C solution of dimethyl malate **F-1** (7.71 g, 47.6 mmol) in THF (130 mL). The mixture was warmed to -20 °C over 2 h, and then cooled to -78 °C. Crotyl bromide (8.1 g, 60 mmol) was added, then the mixture was allowed to warm to room temperature and then stirred overnight. The solution was then cooled to -10 °C and quenched with NH₄Cl (10%, 100 mL). The THF was removed and the residue extracted with ethyl acetate (2x200 mL). The combined organic layers were washed with HCl (1N, 3x50 mL), saturated aqueous sodium bicarbonate (3x50 mL), and brine, then dried over Na₂SO₄. The solution was filtered and concentrated to give a residue, which was purified on silica gel (ethyl acetate/hexane 1:4) to afford (2*S*,3*R*)-3-(2-butenyl)-2-hydroxysuccinic dimethyl ester **F-2** (2.5 g, 24%).

Step 2

To (2*S*,3*R*)-3-(2-butenyl)-2-hydroxysuccinic dimethyl ester **F-2** (2.5 g) in ethyl acetate (50 mL) was added 10 % Pd/C (0.25g) and the reaction stirred under a hydrogen atmosphere for 20 h. The suspension was filtered through a pad of Celite,

washed with EtOAc (3x) and then concentrated *in vacuo* to afford (2*S*,3*R*)-3-(*n*-butyl)-2-hydroxysuccinic dimethyl ester **F-3**.

Step 3

To (2*S*,3*R*)-3-(*n*-butyl)-2-hydroxysuccinic dimethyl ester **F-3** in methanol (28 mL) was added a solution of NaOH (2.2 g, 55 mmol) in water (28 mL). After 24 h the MeOH was removed, the crude reaction was acidified with HCl (6*N*, 12 mL) to pH = 1, and then extracted with ethyl acetate (3 x 50mL). The combined organic layers were dried (Na₂SO₄) and concentrated to give (2*S*,3*R*)-3-(*n*-butyl)-2-hydroxysuccinic acid **F-4** (1.96 g, 90%).

Step 4

To a solution of (2*S*, 3*R*)-3-(*n*-butyl)-2-hydroxysuccinic acid **F-4** (300 mg, 1.58 mmol) in 2,2-dimethoxypropane (10 mL) was added p-toluenesulfonic acid (20 mg) and the reaction was stirred at room temperature for 16 h. The solution was diluted with dichloromethane and washed with brine, dried (Na₂SO₄) and then purified by silica gel chromatography to afford 1.2 mmol 2-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)hexanoic acid **F-5** (78 %).

Step 5

To a solution of 2-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)hexanoic acid **F-5** (1.2 mmol) in DCM (10 mL) was added L-Pro-OBn (1.2 mmol), PyBOP (1.2 mmol), and DIEA (2.5 mmol). The mixture was stirred overnight, then concentrated, and purified on silica gel (ethylacetate/hexane 1:4) to afford 275 mg of the desired amide (45%). To the product in ethylacetate (25 mL) was added 10 % Pd/C (50 mg) and the reaction stirred under a hydrogen atmosphere for 8 h. The suspension was filtered through a pad of Celite, washed with EtOAc (3x) and then concentrated *in vacuo* to afford 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(*S*)-carboxy-pyrrolidin-1-ylcarbonyl)pentane **F-6** (quant.).

Step 6

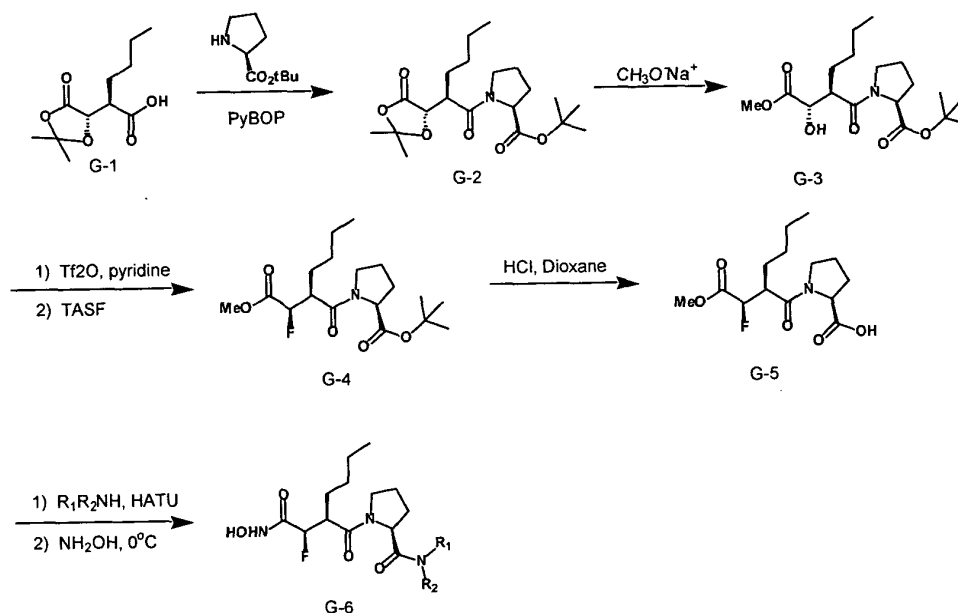
To 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(*S*)-carboxy-pyrrolidin-1-ylcarbonyl)pentane **F-6** (50 mg) in dioxane (1 mL) was added an amine RNH₂ (1 equivalent), DIEA (2.5 equivalents) and HATU or PyBOP (1 equivalent) and the solution stirred for 4 h. The reaction was then cooled to 0 °C, 50 % aqueous hydroxylamine was added (400 µL), and the solution stirred at 4 °C for 8 hours. The

crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford N-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-hydroxypropionamide **F-7**.

5

GENERAL PROCEDURE G

Synthesis of N-hydroxy-3-(*S*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]-2-(*R*)-fluoropropionamide



10 Step 1

To 2-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)hexanoic acid **G-1** (10 mmol; prepared as described in Method F, above) in DMF (50 mL) was added proline O-*t*-butyl ester (10 mmol), DIEA (25 mmol) and PyBOP (10 mmol) and the solution stirred for 8 h. The reaction was diluted with ethyl acetate and washed with water, sodium bicarbonate, brine, and then dried (Na_2SO_4). The filtrate was concentrated and then purified on silica gel (Merck 60; ethyl acetate/hexane) to afford 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl)pentane **G-2** (5 mmol, 50 %).

20

Step 2

To 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-ylcarbonyl)pentane **G-2** (5 mmol, 50 %) (5 mmol) in methanol (20 mL) was added sodium methoxide (catalytic; pH adjusted to 10) and the solution
5 stirred for 1 hour. Amberlite IR-120 resin (H^+ form) was added, then the solution was filtered and concentrated to afford methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl)-2-(*S*)-hydroxypropionate **G-3** (quant.).

Step 3

To methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl)-2-(*S*)-hydroxypropionate **G-3** (5 mmol) in DCM (5 mL) was added pyridine
10 (15 mmol), the reaction was cooled to $-20\text{ }^{\circ}\text{C}$, then triflic anhydride was added (7.5 mmol). The solution was stirred for 1 hour, then washed with aqueous citric acid, sodium bicarbonate and brine, then dried (Na_2SO_4) and concentrated. The intermediate triflate was then resuspended in DCM and cooled to $-50\text{ }^{\circ}\text{C}$.
15 Tris(dimethylamino)sulfur (trimethylsilyl)difluoride (TAS-F) was added (5 mmol) and the solution allowed to warm to rt. The reaction mixture was washed with aqueous sodium bicarbonate and brine, dried (Na_2SO_4) and concentrated then purified on silica gel (ethylacetate/hexanes) to afford 2.3 mmol (45 %) of methyl 3-(*S*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl)-2-(*R*)-fluoropropionate
20 **G-4**.

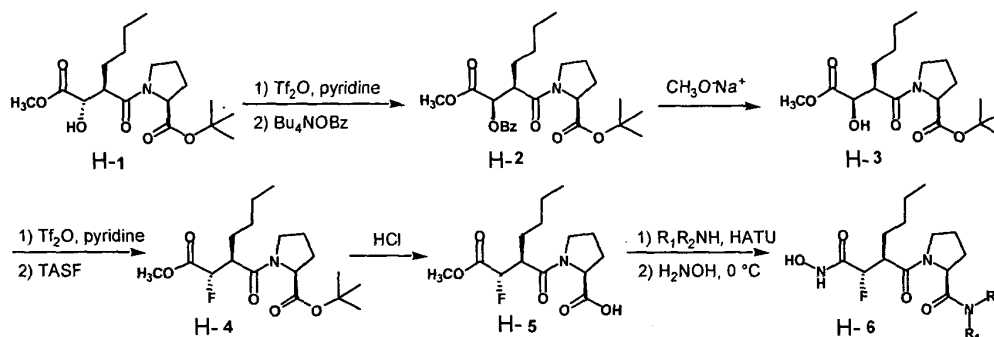
Step 4

To methyl 3-(*S*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl)-2-(*R*)-fluoropropionate **G-4** (2.3 mmol) was added 4 N HCl in dioxane (10 mL), the solution stirred for 2 h, then evaporated to dryness to afford 2.3 mmol of
25 methyl 3-(*S*)-*n*-butyl-3-[2-(*S*)-carboxypyrrolidin-1-yl-carbonyl)-2-(*R*)-fluoropropionate **G-5** (quant.). To intermediate **G-5** (0.15 mmol) in dioxane (1 mL) was added an amine (0.15 mmol), DIEA (0.38 mmol), and HATU or other coupling reagent (0.15 mmol) and the solution stirred for 8 h. The reaction was cooled to $0\text{ }^{\circ}\text{C}$, aqueous 50 % hydroxylamine was added (0.5 mL) and the reaction stirred for 4 h.
30 The crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford N-hydroxy- 3-(*S*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl)-2-(*R*)-fluoropropionamide **G-6**.

GENERAL PROCEDURE H

Synthesis of N-hydroxy-3-(*S*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-fluoropropionamide

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Step 1

To methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-hydroxypropionate **H-1** (10 mmol; prepared as described in Method G, above) in DCM (10 mL) was added pyridine (30 mmol), the reaction was cooled to –20 °C then triflic anhydride (15 mmol) was added. The solution was stirred for 1 hour, then washed with aqueous citric acid, sodium bicarbonate and brine, then dried (Na₂SO₄) and concentrated. The resulting oil was dissolved in toluene (30 mL), cooled to 0 °C, then treated with tetrabutylammonium benzoate. After 1.5 h, the reaction was concentrated and then purified on silica gel (ethylacetate/hexanes) to afford 8.7 mmol of methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl]-2-(*R*)-benzoyloxypropionate **H-2** (87 %).

Step 2

To methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl]-2-(*R*)-benzoyloxypropionate **H-2** (8.7 mmol) in methanol (25 mL) at 0 °C was added sodium methoxide (catalytic; pH adjusted to 10) and the solution stirred for 2 h. Amberlite IR-120 resin (H⁺ form) was added, then the solution was filtered and concentrated to afford methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl]-2-(*R*)-hydroxypropionate **H-3** (quant.).

Step 3

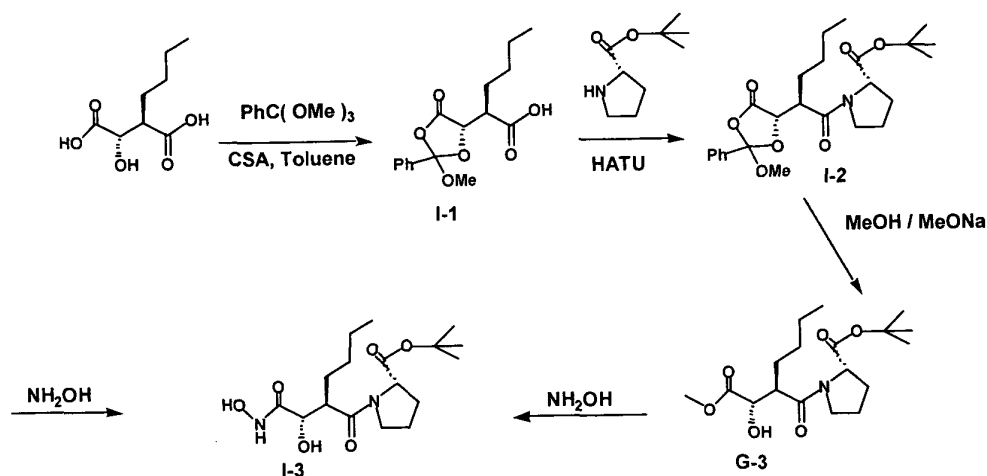
To methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl]-2-(*R*)-hydroxypropionate **H-3** (8.7 mmol) in DCM (10 mL) was added pyridine (25 mmol), the reaction was cooled to -20 °C, then triflic anhydride (12.5 mmol) was added. The solution was stirred for 1 hour, then worked up as described above. The intermediate triflate was resuspended in DCM and cooled to -50 °C. Tris(dimethylamino)sulfur (trimethylsilyl)difluoride (TAS-F) was added (8.7 mmol) and the solution allowed to warm to rt. The reaction mixture was washed with aqueous sodium bicarbonate and brine, dried (Na₂SO₄) and concentrated, then purified on silica gel (ethylacetate/hexanes) to afford 4.3 mmol (50 %) of methyl 3-(*S*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-fluoropropionate **H-4**.

Step 4

To methyl 3-(*S*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxycarbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-fluoropropionate **H-4** (4.3 mmol) was added 4 N HCl in dioxane (15 mL), the solution stirred for 2 h, then evaporated to dryness to afford 4.3 mmol of methyl 3-(*S*)-*n*-butyl-3-[2-(*S*)-carboxypyrrolidin-1-yl-carbonyl]-2-(*S*)-fluoropropionate **H-5** (quant.). To **H-5** (0.15 mmol) in dioxane (1 mL) was added an amine (0.15 mmol), DIEA (0.38 mmol), and HATU or similar coupling reagent (0.15 mmol) and the solution stirred for 8 h. The reaction was cooled to 0 °C, aqueous 50 % hydroxylamine was added (0.5 mL) and the reaction stirred for 4 h. The crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford *N*-hydroxy-3-(*S*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-fluoropropionamide **H-6**.

GENERAL PROCEDURE I

Synthesis of *N*-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-yl-carbonyl]-2-(*S*)-hydroxypropionamide



Step 1

To a solution of (2S,3R)-3-(n-butyl)-2-hydroxysuccinic acid **F-4** (300 mg, 1.58 mmol) and powdered molecular sieves (1 g) in trimethyl orthobenzoate (5 mL) and toluene (5 mL) was added 10-Camphorsulfonic acid (20 mg) and the reaction was heated at 110°C under vacuum (20 torr) for 5 h. The solution was diluted with ethyl acetate, filtered through Celite and washed with brine, dried (Na_2SO_4) and then purified by silica gel chromatography to afford 1.2 mmol 2-(2-methoxy-2-phenyl-4-oxo-1,3-dioxolan-5-yl)hexanoic acid **I-1** (40 %).

Step 2

To 2-(2-methoxy-2-phenyl-4-oxo-1,3-dioxolan-5-yl)hexanoic acid **I-1** (10 mmol; prepared as described in Method I, above) in DMF (50 mL) was added proline O-t-butyl ester (10 mmol), DIEA (25 mmol) and PyBOP (10 mmol) and the solution stirred for 8 h. The reaction was diluted with ethyl acetate and washed with water, sodium bicarbonate, brine, and then dried (Na_2SO_4). The filtrate was concentrated and then purified on silica gel (Merck 60; ethyl acetate/hexane) to afford 1-(2-methoxy-2-phenyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(S)-tert-butoxycarbonylpyrrolidin-1-yl-carbonyl)pentane **I-2** (5 mmol, 50 %).

Step 3

To 1-(2-methoxy-2-phenyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(S)-tert-butoxycarbonylpyrrolidin-1-yl-carbonyl)pentane **I-2** (5 mmol, 50 %) (5 mmol) in methanol (20 mL) was added sodium methoxide (catalytic; pH adjusted to 10) and the solution

stirred for 1 hour. Amberlite IR-120 resin (H⁺ form) was added, then the solution was filtered and concentrated to afford methyl 3-(*R*)-*n*-butyl-3-[2-(*S*)-*tert*-butoxy-carbonylpyrrolidin-1-yl-carbonyl]-2-(*S*)-hydroxypropionate **G-3** (quant.).

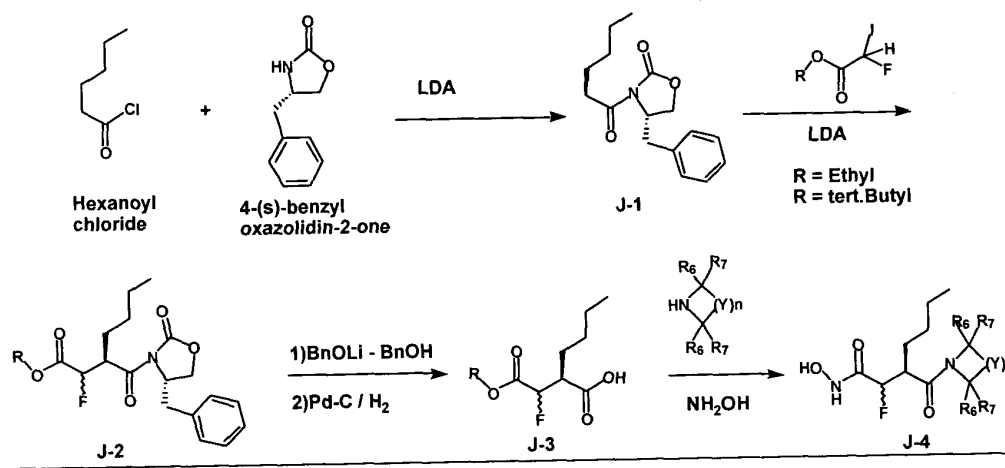
Step 4

- 5 To **G-3** and **I-2** (50mg) in dioxane (1 mL) was added aqueous 50 % hydroxylamine (0.5 mL) and the reaction stirred for 16 h. The crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford N-hydroxy-3-(*R*)-*n*-butyl-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-yl-carbonyl]-2-(*S*)-hydroxypropionamide.

10

GENERAL PROCEDURE J

Synthesis of N-hydroxy-3-(*S*)-*n*-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]-2-(*RS*)-fluoropropionamide



Step 1

- 20 To a solution of 4-(*S*)-benzyloxazolidin-2-one (56 mmol) (Aldrich, Milwaukee, Wisconsin) in THF at -78°C was added 2.5 M *n*-BuLi in hexane (22.4 mL, 56 mmol) and the reaction stirred at -78°C for 2 hr. To this was added via cannula a -78°C solution of hexanoyl chloride (65 mmol) in THF and the mixture stirred at -78°C for 2 hr, then allowed to warm to room temperature and stirred overnight. The reaction was then quenched with aqueous saturated NH₄Cl, extracted

with ethyl acetate, dried, and purified by silica gel chromatography (hexanes/ethyl acetate) to afford *N*-hexanoyl-4-(*S*)-benzyloxazolidin-2-one **J-1**.

Step 2

To a solution of *N*-hexanoyl-4-(*S*)-benzyloxazolidin-2-one (7.3 mmol) in THF at -78 °C was added 1.0 M sodium hexamethyldisilazide (NaHMDS, 8.8 mmol) and the reaction stirred at -78 °C for 1 hr. A solution of alkyl iodofluoroacetate (8.8 mmol) in THF was then added dropwise, and the resulting mixture was stirred at -78 °C for 1 hr and then at room temperature overnight. The reaction was quenched with NH₄Cl, concentrated, then suspended in ethyl acetate and washed with 0.5 N HCl and brine, dried, and purified by silica gel chromatography (ethyl acetate/hexanes) to afford the alkyl 3-(*S*)-(n-butyl)-3-[4-(*S*)-benzyloxazolidin-2-one-3-ylcarbonyl]-2-(*RS*)-(fluoro)propionate **J-2**.

Step 3

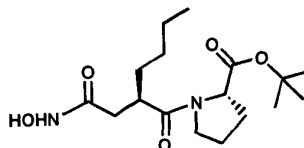
To alkyl 3-(*S*)-(n-butyl)-3-[4-(*S*)-benzyloxazolidin-2-one-3-ylcarbonyl]-2-(*RS*)-(fluoro)propionate (1.44 mmol) in THF at 0°C was added LiOBn (5.76 mmol) in benzyl alcohol and the reaction stirred at 0°C for 3 hr. The reaction was then quenched with 5% KHSO₄, concentrated, suspended in ethyl acetate and subjected to standard aqueous workup. The crude product was purified by silica gel chromatography (methanol/dichloromethane) to afford alkyl 3-(*R*)-(n-butyl)-2-(*RS*)-(fluoro)propionate **J-3**.

Step 4

To **J-3** (0.15 mmol) in dioxane (1 mL) was added an amine (0.15 mmol), DIEA (0.38 mmol), and HATU or similar coupling reagent (0.15 mmol) and the solution stirred for 8 h. The reaction was cooled to 0 °C, aqueous 50 % hydroxylamine was added (0.5 mL) and the reaction stirred for 4 h. The crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford *N*-hydroxy-3-(*S*)-n-butyl-3-[2-(*S*)-aminocarbonylpyrrolidin-1-yl-carbonyl]-2-(*RS*)-fluoropropionamide **J-4**.

Example 1

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide



5

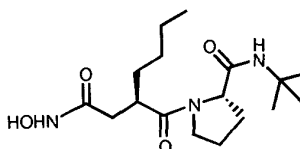
The title compound was prepared according to General Procedure A from *mono*-methyl 2-(*R*)-butylsuccinic acid and L-proline *tert*-butyl ester. This compound has also been prepared according to General Procedure D using L-proline *tert*-butyl ester as the amine. ¹H NMR (300 MHz, CDCl₃) δ 0.89 (t, J=7.2 Hz, 3 H), 1.43 (s, 9H), 1.24-1.71 (m, 6H), 1.86-2.43 (m, 5H), 2.53 (dd, J=10.5 and 13.2 Hz, 1 H), 3.06 (m, 1H), 3.45-3.80 (m, 2H), 4.28-4.40 (m, 1H).

10

Example 2

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butylaminocarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide

15



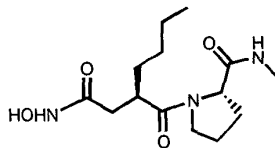
The title compound was prepared according to General Procedure A from *mono*-methyl 2-(*R*)-butylsuccinic acid and L-proline *t*-butylamide hydrochloride. ¹H NMR (300 MHz, CDCl₃) : δ 0.77 (t, J=7.2 Hz, 3H), 1.19 (s, 9H), 1.28-2.00 (m, 10H), 2.08 (dd, J= 4.1 and 9.6 Hz, 1H), 2.26 (dd, J =9.6 and 15 Hz, 1H), 2.99 (m, 1H), 3.47 (m, 1H), 3.63 (dd, J=9.0 and 16.8 Hz, 1H), 4.28 (dd, J=1.9 and 7.8 Hz, 1H).

20

25

Example 3

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methylaminocarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide



5

Small-scale synthesis

The title compound was prepared according to General Procedure A from *mono*-methyl 2-(*R*)-butylsuccinic acid and L-proline methylamide hydrochloride. ¹H NMR (300 MHz, CDCl₃): δ 0.80 (t, J=7.2 Hz, 3H), 1.28-2.50 (m, 12H), 2.98 (m, 1H), 3.47 s, 3H), 3.58 (m, 2H), 4.27 (m, 1H).

10

Large-scale synthesis

Step 1

To a solution of Boc-Pro-OH (5 g, 23.2 mmol), methylamine (2M in THF, 15 mL, 30 mmol), EDC (4.79 g, 25 mmol), and HOBt (3.38 g, 25 mmol) in THF (150 mL) was added DIEA (4.35 mL, 25 mmol) and the mixture stirred overnight. THF was removed, the residue was dissolved in ethyl acetate and then washed with aqueous HCl (1 N, 2x), 5% KHSO₄ (2x), saturated sodium bicarbonate, brine, dried (Na₂SO₄), concentrated, and purified on silica gel (Merck 60, ethyl acetate/hexanes) to give N-Boc-(2-methylaminocarbonyl)pyrrolidine (3.3 g, 63%).

15

Step 2

N-Boc-(2-methylaminocarbonyl)pyrrolidine (3.3 g, 14.5 mmol) was treated with HCl (4 N in dioxane, 10 mL) for 1 h. The solvent was removed and the white solid treated with *mono*-methyl 2-(*R*)-butylsuccinic acid (2.82 g, 15 mmol), HOBt (2.02 g, 15 mmol), EDC (2.88 g, 15 mmol) and DIEA (6.96 mL, 40 mmol) in THF for 16 h. Similar work-up and purification gave the methyl ester (2.2 g). A solution of methyl ester and lithium hydroxide (400 mg, 10 mmol) in methanol (15 mL) and water (10 mL) was stirred for 16 h. Methanol was removed and the aqueous layer was acidified to pH =1 and extracted with ethyl acetate (4x). The organic layers were

20

25

dried (Na₂SO₄) and concentrated to afford 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methylamino-carbonyl)pyrrolidin-1-ylcarbonyl]propionic acid as a white solid (1.5 g).

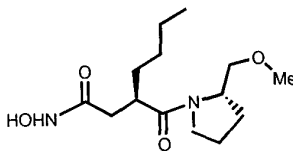
Step 3

To a solution of 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methylaminocarbonyl)-pyrrolidin-1-ylcarbonyl]propionic acid (1.5 g, 5.28 mmol), O-benzylhydroxylamine (932 mg, 5.84 mmol), HOBt (784 mg, 5.84 mmol), and DIEA (2.3 mL, 13.2 mmol) in THF (100 mL) was added EDC (1.12 g, 5.84 mmol) and the reaction stirred for 16 h. Conventional work-up and purification gave *N*-benzyloxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methylaminocarbonyl)pyrrolidin-1-ylcarbonyl]propionamide (1.56 g).

A solution of *N*-benzyloxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methylaminocarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide (1.5 g) in ethyl acetate (50 mL) was hydrogenated over Pd/C for 14 h. The mixture was filtered through a pad of Celite, washed with ethyl acetate, and concentrated to give *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methylamino-carbonyl)pyrrolidin-1-ylcarbonyl]propionamide (1.1 g).

Example 4

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methoxymethyl)-pyrrolidin-1-ylcarbonyl]propionamide



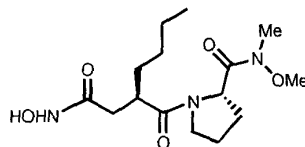
20

The title compound was prepared according to General Procedure A from (*S*)-(+)-2-(methoxymethyl)pyrrolidine and *mono*-methyl 2-(*R*)-butylsuccinic acid. ¹H NMR (300 MHz, CDCl₃): δ 0.90 (t, J=7.5 Hz, 3H), 1.22-1.64 (m, 6H), 1.84-2.05 (m, 2H), 1.84-2.05 (m, 2H), 2.25-2.42 (m, 1H), 2.51-2.66 (m, 1H), 2.99-3.16 (m, 1H), 3.33 (s, 3H), 3.38 (dd, J=1.9 and 6.9 Hz, 1H), 3.44 (bd, J = 6.9 Hz, 1H), 3.47-3.54 (m, 1H), 3.61-3.69 (m, 1H), 4.24 (m, 1H).

25

Example 5

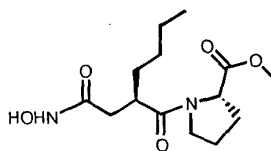
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(N-methoxy-N-methylamino-carbonyl)pyrrolidin-1-ylcarbonyl]propionamide



- 5 The title compound was prepared according to General Procedure A from L-proline N-methoxyl N-methylamide hydrochloride and *mono*-methyl 2-(*R*)-butylsuccinic acid. ¹H NMR (300 MHz, CDCl₃): δ 0.80 (t, J=7.2 Hz, 3H), 1.27-2.60 (m, 12H), 3.05 (m, 1H), 3.19 (s, 3H), 3.72 (m, 2H), 3.78 (s, 3H), 4.85 (m, 1H).

Example 6

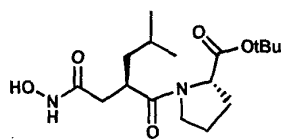
- 10 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(methoxycarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide .



- 15 The title compound was prepared according to General Procedure A from L-proline methyl ester hydrochloride and *mono*-methyl 2-(*R*)-butylsuccinic acid. ¹H NMR (300 MHz, CDCl₃): δ 0.90 (m, 3H), 1.23-1.70 (m, 6H), 1.86-2.09 (m, 3H), 2.15-2.62 (m, 3H), 3.01-3.17 (m, 1 H), 3.59 –3.86 (m, 2H), 3.71 (s, 3H), 4.42-4.53(m, 1H).

Example 7

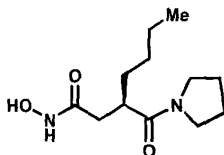
- 20 Synthesis of *N*-hydroxy-3-(*R*)-(3-methylpropyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionamide



The title compound was prepared according to General Procedure A from L-proline *t*-butyl ester hydrochloride and *mono*-methyl 2-(*R*)-isobutylsuccinic acid. ¹H NMR (300 MHz, CDCl₃): δ 0.90-0.99 (m, 6H), 1.27-2.58 (m, 18H), 2.78-2.91 (m, 1H), 3.08-3.18 (m, 1H), 3.43-3.81 (m, 3H), 4.26-4.40 (m, 2H).

Example 8

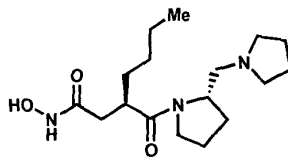
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-(pyrrolidin-1-ylcarbonyl)propionamide



The title compound was prepared according to General Procedure A using pyrrolidine as the amine and *mono* methyl-2-(*R*)-butylsuccinic acid. MS (APCI) *m/z* = 243 [M+H].

Example 9

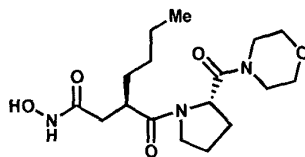
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(pyrrolidin-1-ylmethyl)-pyrrolidin-1-ylcarbonyl]propionamide



The title compound was prepared according to General Procedure A from 2-(*S*)-(pyrrolidin-1-ylmethyl)pyrrolidine and *mono*-methyl 2-(*R*)-butylsuccinic acid. MS (APCI) *m/z* = 326 [M+H].

Example 10

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(morpholin-4-ylcarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide

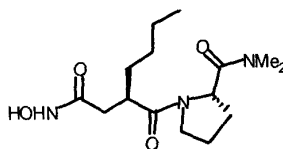


5

The title compound was prepared according to General Procedure D using L-proline N-morpholinylamide as the amine. MS (APCI) $m/z = 356$ [M+H].

Example 11

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(dimethylaminocarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide



10

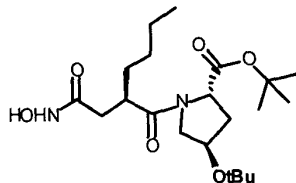
15

The title compound was prepared according to General Procedure A from L-proline N,N-dimethylamide hydrochloride and *mono*-methyl 2-(*R*)-butylsuccinic acid. MS (APCI) $m/z = 314$ [M+H].

Example 12

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[4-(*R*)-(tert-butoxy-2-(*S*)-tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionamide

20

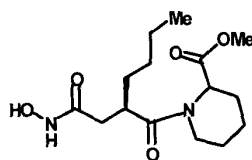


The title compound was prepared according to General Procedure A from 3-(*R*)-*O*-*tert*-butoxy-L-proline *t*-butyl ester and *mono*-methyl 2-(*R*)-butylsuccinic acid.

5 MS (APCI) $m/z = 415$ [M+H].

Example 13

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(methoxycarbonyl)piperidin-1-ylcarbonyl]propionamide

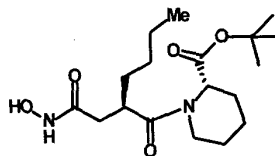


10

The title compound was prepared according to General Procedure A from (±)-homoproline methyl ester and *mono*-methyl 2-(*R*)-butylsuccinic acid. MS (APCI) $m/z = 315$ [M+H].

Example 14

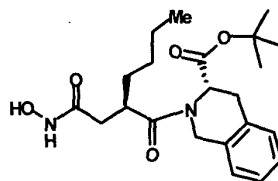
15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)piperidin-1-ylcarbonyl]propionamide



20 The title compound was prepared according to General Procedure D using L-homoproline *t*-butyl ester as the amine. MS (APCI) $m/z = 357$ [M+H].

Example 15

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-tetrahydroisoquinolin-1-ylcarbonyl]propionamide



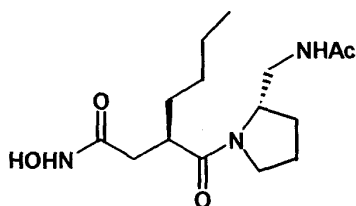
5

The title compound was prepared according to General Procedure A from L-tetrahydroisoquinoline t-butyl ester and *mono*-methyl 2-(*R*)-butylsuccinic acid. MS (APCI) $m/z = 405$ [M+H].

10

Example 16

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(acetamidomethyl)pyrrolidin-1-ylcarbonyl]propionamide



15 Step 1

To a solution of 4-(*S*)-benzyloxazolidin-2-one (56 mmol) (Aldrich, Milwaukee, Wisconsin) in THF at -78°C was added 2.5 M *n*-BuLi in hexane (22.4 mL, 56 mmol) and the reaction stirred at -78°C for 2 hr. To this was added via cannula a -78°C solution of hexanoyl chloride (65 mmol) in THF and the mixture stirred at -78°C for 2 hr, then allowed to warm to room temperature and stirred overnight. The reaction was then quenched with aqueous saturated NH_4Cl , extracted

with ethyl acetate, dried, and purified by silica gel chromatography (hexanes/ethyl acetate) to afford *N*-hexanoyl-4-(*S*)-benzyloxazolidin-2-one.

Step 2

To a solution of *N*-hexanoyl-4-(*S*)-benzyloxazolidin-2-one (7.3 mmol) in THF at -78°C was added 1.0 M sodium hexamethyldisilazide (NaHMDS, 8.8 mmol) and the reaction stirred at -78°C for 1 hr. A solution of methyl bromoacetate (8.8 mmol) in THF was then added dropwise, and the resulting mixture was stirred at -78°C for 1 hr and then at room temperature overnight. The reaction was quenched with NH_4Cl , concentrated, then suspended in ethyl acetate and washed with 0.5 N HCl and brine, dried, and purified by silica gel chromatography (ethyl acetate/hexanes) to afford the methyl 3-(*R*)-(n-butyl)-3-[4-(*S*)-benzyloxazolidin-2-one-3-ylcarbonyl]propionate.

Step 3

To methyl 3-(*R*)-(n-butyl)-3-[4-(*S*)-benzyloxazolidin-2-one-3-ylcarbonyl]-propionate (1.44 mmol) in THF/water at 0°C was added 30% H_2O_2 (5.76 mmol) and solid lithium hydroxide (1.44 mmol) and the reaction stirred at 0°C for 3 hr. The reaction was then quenched with 2.0 M Na_2SO_3 , concentrated, suspended in ethyl acetate and subjected to standard aqueous workup. The crude product was purified by silica gel chromatography (methanol/dichloromethane) to afford methyl 3-(*R*)-(n-butyl)-propionate.

Step 4

To Boc-L-prolinol (1 mmol) (Advanced Chemtech, Louisville, KY) in THF at 0°C was added mesitylenesulfonylchloride (MsCl, 1.2 mmol) and DIEA (1.5 mmol) and the solution allowed to warm to rt, then stirred an additional hour. Solid sodium azide was added (1.5 mmol) and the reaction was allowed to stir overnight. Conventional aqueous workup followed by silica gel chromatography afforded the N-Boc-(*S*)-(2-azidomethyl)pyrrolidine.

Step 5

A solution of the N-Boc-(*S*)-(2-azidomethyl)pyrrolidine in ethylacetate was added to 10% Pd/C and the reaction evacuated and flushed with hydrogen gas three times. The reaction was then stirred under a hydrogen atmosphere overnight, then filtered through a pad of celite and concentrated to dryness. The resulting amine was dissolved in DMF and then acylated with acetic anhydride to afford the N-Boc-(*S*)-(2-

acetamidomethyl)pyrrolidine. The Boc group was deprotected with 1N HCl in dioxane to afford the desired (*S*)-(2-acetamidomethyl)pyrrolidine.

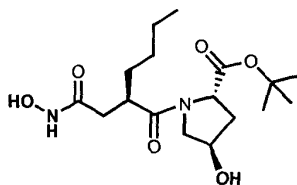
Step 6

- The title compound was prepared from (*S*)-(2-acetamidomethyl)pyrrolidine and methyl 3-(*R*)-(n-butyl)propionate according to General Procedure A.
- MS (APCI) m/z = 314 [M+H].

Example 17

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(4-(*R*)-hydroxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionamide

10



Small-scale synthesis

Step 1

- Cbz-protected *trans*-3-hydroxy-L-proline (20 g, 75 mmol) in DCM was treated with 60 ml of acetic anhydride and 10 mL of pyridine. The solution was stirred at rt for 18 hours, then the reaction was quenched with icewater, extracted with EtOAc (3 x 200 mL), and the organic layer washed with water, brine, and dried over MgSO₄. Concentration *in vacuo* gave Cbz-protected *trans*-3-acetoxy-L-proline as a colorless oil.

Step 2

- To a solution of Cbz-protected *trans*-3-acetoxy-L-proline (75 mmol) in dry dioxane was added *tert*-butyl alcohol (14.2 mL, 150 mmol), diisopropylcarbodiimide (23 mL, 147 mmol), and DMAP (2.3 g) and the mixture was stirred at rt for two days. The reaction was concentrated to an oil and purified via silica gel chromatography (hexanes/ethyl acetate) to afford the desired Cbz-protected *trans*-3-acetoxy-L-proline *t*-butyl ester. ESMS (negative): 362 (M-1).

Step 3

To Cbz-protected *trans*-3-acetoxy-L-proline t butyl ester (1 mmol) in ethyl acetate (10 mL) was added 10% Pd/C and the reaction evacuated and flushed with hydrogen gas three times. The reaction was then stirred under a hydrogen atmosphere overnight, then filtered through a pad of celite and concentrated to dryness to afford the desired *trans*-3-acetoxy-L-proline t-butyl ester. MS (APCI negative) *m/z* 357 [M-H]. ¹H NMR (300 MHz, CD₃OD) δ 4.0 (m, 2H), 3.75 (m, 2H), 3.10 (m, 1H), 2.85 (m, 1H), 2.40 (m, 2H), 2.2 (m, 2H), 2.0 (m, 2H), 1.65 to 1.0 (m, 15H), 0.90 (m, 3H).

Step 4

The title compound was prepared according to General Procedure A using *trans*-3-acetoxy-L-proline O-t-butyl ester and methyl 3-(*R*)-(n-butyl)propionate. The final treatment with hydroxylamine removed the acetyl group from the 3-hydroxy group of the proline.

Large-scale synthesis

Step 1

To *trans*-3-acetyloxy-L-proline t-butyl ester (11.8 mmol) in DCM (60 mL) was added *mono*-methyl 2-(*R*)-butylsuccinic acid (11.2 mmol), DIEA (23.6 mmol) and PyBOP (11.8 mmol) and the solution stirred for 16 h. The reaction was concentrated to an oil and purified on silica gel (Merck 60; hexanes/ethylacetate) to afford 2.2 g of methyl 3-(*R*)-(n-butyl)-3-[(4-(*R*)-acetoxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionate as a clear oil **5** (50%).

Step 2

To methyl 3-(*R*)-(n-butyl)-3-[(4-(*R*)-acetoxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionate (5.5 mmol) in methanol (25 mL) was added water (1 mL) and LiOH-H₂O (12.1 mmol) and the solution stirred 20 h. Standard aqueous work-up afforded 3-(*R*)-(n-butyl)-3-[(4-(*R*)-hydroxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionic acid 2 g of a colorless oil which solidified upon standing (quant.).

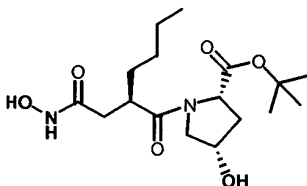
Step 3

To a solution of 3-(*R*)-(n-butyl)-3-[(4-(*R*)-hydroxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionic (5.51 mmol) in DCM (30 mL) was added O-

benzylhydroxylamine-HCL (6.06 mmol), DIEA (13.3 mmol) and PyBOP and the solution stirred for 18 h. Standard aqueous work-up followed by silica gel chromatography (Merck 60; ethylacetate) afforded 1.14 g of the protected N-benzyloxy- 3-(*R*)-(n-butyl)-3-[(4-(*R*)-hydroxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionamide as a white gum (45%). This was dissolved in ethylacetate (50 mL), 5% Pd/C was added (110 mg), and a hydrogen atmosphere introduced. After 16 h the reaction was filtered through celite and concentrated to afford 810 mg of the title compound as a white foam (89%).

Example 18

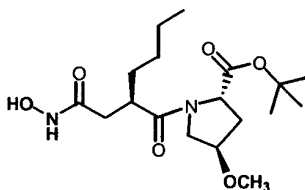
10 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(4-(*S*)-hydroxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionamide



15 To methyl 3-(*R*)-(n-butyl)-3-[(4-(*R*)-hydroxy-2-(*S*)-*tert*-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]propionate (prepared by General Procedure A, omitting the final treatment with NH₂OH) in THF was added chloroacetic acid, TPP and DIAD and the reaction stirred 18 h. The chloroacetate ester was purified on silica gel (Merck 60; hexanes/ethylacetate), dissolved in dioxane and then treated with aqueous 50% hydroxylamine. The reaction mixture was purified by preparative reverse-phase (C18) HPLC to afford the title compound. MS (APCI negative) *m/z* 357 [M-H].

Example 19

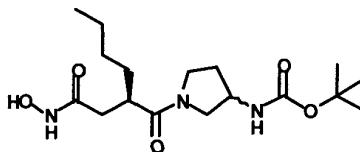
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(4-(*R*)-methoxy-2-(*S*)-*tert*-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]propionamide



To methyl 3-(*R*)-(n-butyl)-3-[(4-(*R*)-hydroxy-2-(*S*)-*tert*-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]propionate in THF at 0 °C was added sodium hydride (60% dispersion in mineral oil) and the mixture stirred for 1 h. Iodomethane was added,
 5 and the reaction allowed to warm to rt and then stirred an additional 2 h. Standard aqueous work-up followed by purification on silica gel afforded the penultimate methyl ester. This was dissolved in dioxane and then treated with aqueous 50% hydroxylamine for 48 h. The reaction mixture was purified by preparative reverse-phase (C18) HPLC to afford the title compound. MS (APCI negative) m/z 371 [M-
 10 H].

Example 20

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[3-(*RS*)-(tert-butoxycarbonyl-amino)pyrrolidin-1-ylcarbonyl]propionamide

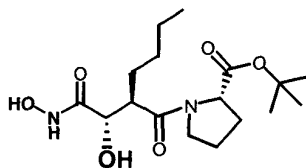


15

The title compound was prepared according to General Procedure B from (±)-3-(N-Boc-amino)pyrrolidine (obtained from TCI America, Portland, Oregon) and *mono*-4-methyl 2-(*R*)-butylsuccinic acid. MS (APCI) m/z 358[M+H].

Example 21

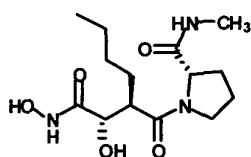
20 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F or I. ¹H NMR (300 MHz, CDCl₃): δ 0.93 (t, J= 7.5 Hz, 3 H), 1.31-1.49 (m, 4H), 1.44 (s, 9H), 1.76-2.23 (m, 6H), 3.23 (dt, J=2.5 and 7.5 Hz, 1H), 3.67-3.77 (m, 1H), 3.55-3.64 (m, 1H), 4.26 (d, J=2.5 Hz, 1H), 4.32 (dd, J=4.2 and 8.7 Hz, 1 H). ES-MS: calcd. For C₁₇H₃₀N₂O₆(358.43); found: 359 [M+1].

Example 22

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(methylaminocarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide

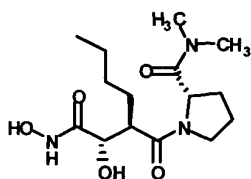


10

The title compound was prepared according to General Procedure C from methylamine. MS (APCI negative) m/z 314 [M-H].

Example 23

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(dimethylaminocarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide



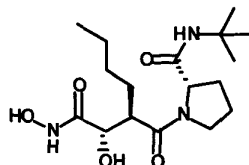
15

The title compound was prepared according to General Procedure C from N,N-dimethylamine. MS (APCI negative) m/z 328 [M-H].

20

Example 24

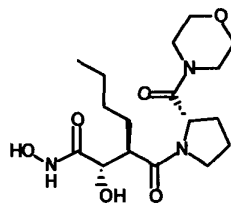
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butylaminocarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide



- 5 The title compound was prepared according to General Procedure C from *t*-butylamine. MS (APCI negative) m/z 356 [M-H].

Example 25

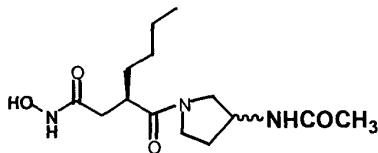
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(morpholin-4-ylcarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide



10 The title compound was prepared according to General Procedure C from morpholine. MS (APCI negative) m/z 370 [M-H].

Example 26

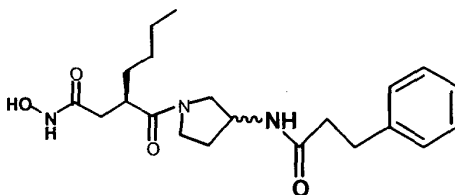
15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[3-(*RS*)-(acetylamino)pyrrolidin-1-ylcarbonyl]propionamide



To methyl 3-(*R*)-(n-butyl)-3-[3-(*RS*)-(tert-butoxycarbonylamino)pyrrolidin-1-ylcarbonyl]propionate, prepared from (±)-3-(*N*-Boc-amino)pyrrolidine (TCI America, Portland, Oregon) and *mono*-4-methyl 2-(*R*)-butylsuccinic acid, was added 4 N HCl in dioxane and the solution stirred for 4 h. The solution was evaporated to dryness, dissolved in dioxane, and then treated with acetic anhydride and pyridine and stirred for 2 h. Aqueous 50% hydroxylamine was added and the solution stirred for 2 d. The crude reaction mixture was purified by preparative reverse-phase (C18) HPLC to afford the title compound. MS (APCI negative) *m/z* 298 [M-H].

Example 27

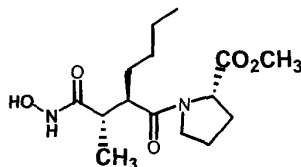
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[3-(*RS*)-(2-phenylethylcarbonylamino)-pyrrolidin-1-ylcarbonyl]propionamide



To methyl 3-(*R*)-(n-butyl)-3-[3-(*RS*)-(tert-butoxycarbonylamino)pyrrolidin-1-ylcarbonyl]propionate, prepared from (±)-3-(*N*-Boc-amino)pyrrolidine and *mono*-4-methyl 2-(*R*)-butylsuccinic acid, was added 4 N HCl in dioxane and the solution stirred for 4 h. The solution was evaporated to dryness, dissolved in dioxane, and then treated with 3-phenylpropionic acid, DIEA, and HATU and stirred for 2 h. Aqueous 50% hydroxylamine was added and the solution stirred for 2 d. The crude reaction mixture was purified by preparative reverse-phase (C18) HPLC to afford the title compound.

Example 28

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(methoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-methylpropionamide



5

Step 1

To mono *t*-butyl 2-(*R*)-(n-butyl)succinic acid (2.0 g, 8.70 mmol; prepared in three steps from hexanoylchloride using the procedure of Example 16, Step A for the synthesis of monomethyl-2-*R*-butylsuccinic acid, with substitution of *t*-butyl bromoacetate for methyl bromoacetate) in anhydrous THF (40 mL) at -78°C was added LDA (2.2 eq., 19.1 mmol, 9.56 ml of a 2.0 M solution in THF/hexane/ethylbenzene) and the reaction stirred for 1 h. Iodomethane (11.3 mmol, 1.6 g) was then added and the reaction allowed to warm to room temperature over 2 h. The solution was quenched with methanol (ca. 5 mL), evaporated to dryness, and the residue dissolved in ethylacetate (50 mL). This solution was extracted with saturated sodium bicarbonate (3 x 30 mL), the combined aqueous layers acidified to pH 3 with 1 N HCl, and these were extracted with ethylacetate (3 x 50 mL). The combined organic layers were dried (Na_2SO_4), concentrated, and purified by silica gel chromatography (Merck 60; 95:5 DCM/methanol) to afford mono *t*-butyl 2-(*R*)-(n-butyl)-3-(*RS*)-methylsuccinic acid as a light orange oil (1.25 g). The ratio of *R/S* diastereomers was > 6:1.

Step 2

An aliquot of mono *t*-butyl 2-(*R*)-(n-butyl)-3-(*RS*)-methylsuccinic acid (1.0 g, 4.10 mmol) was epimerized by first dissolving it in THF (22 mL), cooling to -78°C and then adding LDA (9.02 mmol, 4.52 mL of a 2.0 M solution). The solution was allowed to warm to rt over 2 hours, then cooled back down to -78°C and quenched with methanol (1.7 mL). This epimerization procedure was repeated once more, then an aqueous work-up was performed as described above to afford 700 mg of mono *t*-

butyl 2-(*R*)-(n-butyl)-3-(*RS*)-methylsuccinic acid. ¹H NMR analysis of this product suggested approximately 2:1 ratio of R/S diastereomers.

Step 3

To mono *t*-butyl 2-(*R*)-(n-butyl)-3-(*RS*)-methylsuccinic acid (680 mg, 1.39 mmol, prepared in step 2 above) in DCM (15 mL) was added L-proline methyl ester hydrochloride (3.34 mmol, 554 mg), DIEA (1.28 mL, 7.34 mmol) and then PyBOP (1.74 g, 3.34 mmol). The reaction was stirred for 16 h, concentrated to dryness, and then purified via silica gel chromatography (1:1 hexanes/ethylacetate) to afford mono *t*-butyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-methoxycarbonyl]pyrrolidin-1-ylcarbonyl]-2-(*S*)-methylpropionate (260 mg).

Step 4

The *t*-butyl group was removed from mono *t*-butyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-methoxycarbonyl]pyrrolidin-1-ylcarbonyl]-2-(*S*)-methylpropionate (260 mg, 732 μmol) using 1:2 TFA/DCM, followed by evaporation of the TFA and solvent. To the resulting product in DCM (5 mL) at 0 °C was added O-benzylhydroxylamine hydrochloride (129 mg, 805 μmol), HOBt (112 mg, 732 μmol), DIEA (708 μL, 1.61 mmol) and then solid EDC (154 mg, 805 μmol) and the reaction allowed to warm to rt and then stirred overnight. The reaction was evaporated to dryness, and purified on a silica gel column (1:1 hexanes/ethylacetate) to afford *N*-benzyloxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-methoxycarbonyl]pyrrolidin-1-ylcarbonyl]-2-(*S*)-methylpropionamide as a colorless glass (212 mg).

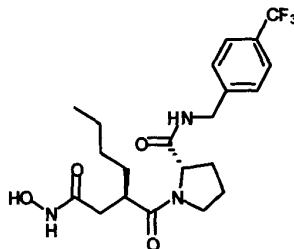
Step 5

To *N*-benzyloxy- 3-(*R*)-(n-butyl)-3-[2-(*S*)-methoxycarbonyl]pyrrolidin-1-ylcarbonyl]-2-(*S*)-methylpropionamide (40 mg) in methanol (3 mL) was added 10% Pd/C (10 mg). The reaction was evacuated briefly under high-vacuum, and the atmosphere replaced with 1 atm hydrogen gas (balloon). This procedure was repeated twice more, then the suspension was stirred under H₂ gas for 3 h. The reaction was then filtered through a plug of celite to afford the title compound as a clear, colorless gum (31 mg). MS (APCI) *m/z* 315 [M+H].

Example 29

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(3-trifluoromethylbenzylamino-carbonyl)pyrrolidin-1-ylcarbonyl]propionamide

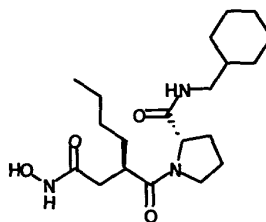
5



The title compound was prepared according to General Procedure D from L-proline-(4-trifluoromethyl)benzylamide. MS (APCI) *m/z* 444 [M+H].

Example 30

10 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(cyclohexylmethaniminocarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide

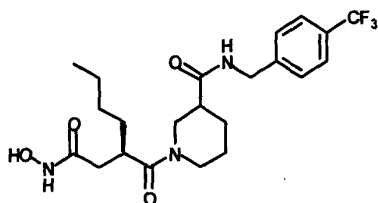


15 The title compound was prepared according to General Procedure A from *mono*-methyl 2-(*R*)-butylsuccinic acid and L-proline-(cyclohexyl)methylamide. MS (APCI) *m/z* 382 [M+H].

Example 31

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[3-(*RS*)-((4-trifluoromethylbenzyl)-aminocarbonyl)piperidin-1-ylcarbonyl]propionamide

20

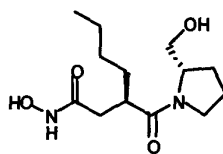


The title compound was prepared according to General Procedure A from *mono*-methyl 2-(*R*)-butylsuccinic acid and (±)-3-carboxypiperidine-(4-trifluoromethylbenzyl)amide. MS (APCI) *m/z* 458 [M+H].

5

Example 32

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(hydroxymethyl)-pyrrolidin-1-ylcarbonyl]propionamide



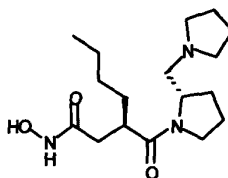
10

The title compound was prepared according to General Procedure A from *mono*-methyl 2-(*R*)-butylsuccinic acid and L-prolinol. MS (APCI) *m/z* 273 [M+H].

Example 33

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(pyrrolidin-1-ylmethyl)-pyrrolidin-1-ylcarbonyl]propionamide

15

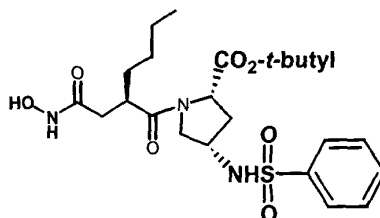


The title compound was prepared according to General Procedure A from *mono*-methyl 2-(*R*)-butylsuccinic acid and (*S*)-2-(*N*-pyrrolidinylmethyl)-pyrrolidine. MS (APCI) *m/z* 326 [M+H].

Example 34

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[4-(*S*)-(phenylsulfonamido)-2-(*S*)-(tert-butyloxycarbonyl)pyrrolidin-1-ylcarbonyl]propionamide

5



Step 1

To mono methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*R*)-hydroxypyrrolidin-1-ylcarbonyl]propionate (1.4g, 3.92 mmol; prepared according to General Procedure A from methyl 2-(*R*)-butylsuccinic acid and *trans*-L-hydroxy-proline *tert*-butyl ester) in DCM at -20°C was slowly added methanesulfonyl chloride (MeSO₂Cl) (0.62mL, 7.84 mmol) and the reaction stirred 4 h. DCM was removed *in vacuo*, and the residue was dissolved in EtOAc (100 mL), washed with saturated NaHCO₃, dilute HCl (5%) and brine and then dried (MgSO₄). Concentration *in vacuo* afforded methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*R*)-mesyloxy-pyrrolidin-1-ylcarbonyl]propionate which was used directly without further purification.

Step 2

To methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*R*)-mesyloxy-pyrrolidin-1-ylcarbonyl]propionate in DMF (30 mL) was added NaN₃ (2.6g) and the resulting solution heated at 65°C for 48. The DMF was removed *in vacuo* and the residue was purified by silica gel column chromatography to afford 1.3 gram of the desired methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*S*)-azido-pyrrolidin-1-ylcarbonyl]propionate.

Step 3

Methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*S*)-azido-pyrrolidin-1-ylcarbonyl]propionate (1.3 g, 3.4 mmol) was hydrogenated at rt with Pd-C (10%)

for 18 h. The reaction was filtered through a pad of celite, and washed with EtOAc. Concentration of the filtrate yielded 1.2 g of methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*S*)-aminopyrrolidin-1-ylcarbonyl]propionate.

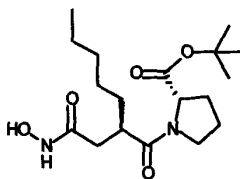
Step 4

- 5 Phenylsulfonyl chloride (2 eq.) was added slowly to a solution of methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*S*)-azido-pyrrolidin-1-ylcarbonyl]-propionate (ca. 0.1 g) in DCM (1 mL) and pyridine (0.1 mL) at 0 °C. The solution was allowed to warm to rt and then stirred an additional 2 h. The solvent was removed *in vacuo*, the residue dissolved in EtOAc (5 mL) and washed with HCl
- 10 solution (5%), NaHCO₃ (sat.) and brine. Concentration *in vacuo* gave the crude methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-*tert*-butoxycarbonyl]-4-(*S*)-phenylsulfonamido-pyrrolidin-1-ylcarbonyl]propionate which was directly converted to the corresponding hydroxamate by treatment with aqueous 50% NH₂OH (1 mL) and dioxane (2 mL) at rt for 3 days. The final product *N*-hydroxy-3-(*R*)-(n-butyl)-3-[4-(*S*)-
- 15 (phenylsulfonamido)-2-(*S*)-(tert-butyloxycarbonyl)pyrrolidin-1-ylcarbonyl]-propionamide was purified by preparative HPLC. ¹H NMR (CD₃OD): δ 7.90 (m, 2H), 7.60 (m, 3H), 4.15(t, J=7.9 Hz, 1H), 4.0 (m, 1H), 3.90 (m, 1H), 3.25(m, 1H), 2.90 (m, 1H), 2.35 (m, 2H), 2.15 (m, 3H), 1.75(m, 1H), 1.60 to 1.20 (m, 13H), 0.90 ppm (s, 3H); MS (APCI negative) m/z 496 [M-1].

20

Example 35

Synthesis of *N*-hydroxy-3-(*R*)-(n-pentyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide

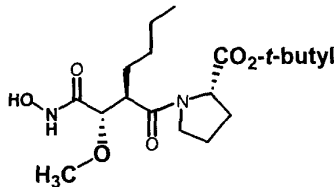


25

The title compound was prepared according to General Procedure A from mono-methyl 2-(*R*)-pentylsuccinic acid and L-proline t-butyl ester. MS (APCI) m/z 357 [M+H].

Example 36

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*S*)-methoxypropionamide



Step 1

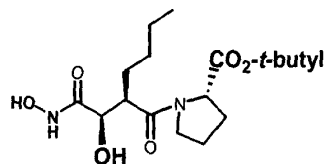
- 5 To 1-(2,2-dimethyl-4-oxo-1,3-dioxolan-5-yl)-1-(2-(*S*)-tert-butoxycarbonylpyrrolidin-1-ylcarbonyl)pentane (4 mmol; prepared as described previously using, *tert*-butyl ester of compound F-6, General Procedure F) in methanol (20 mL) was added 1M MeONa (1ml) and stirred for 1 h. The reaction was neutralized with H⁺ resin, filtered, and the filtrate was concentrated to dryness.
- 10 The residue purified on silica gel to afford methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionate.

Step 2

- To a solution of methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionate (1 mmol) in DMF (10 ml) was
- 15 added NaH. After 30 minutes, methyl iodide (3 mmol) was added and the solution stirred an additional hour. The reaction was then diluted with ethyl acetate, washed with water, dried with Na₂SO₄, filtered and concentrated. The crude methyl ether was dissolved in dioxane, treated with aqueous 50% hydroxylamine, and stirred for two days. The crude reaction mixture was purified by preparative reverse-phase (C18)
- 20 HPLC to afford the title compound. MS (APCI negative) *m/z* 371 [M-H].

Example 37

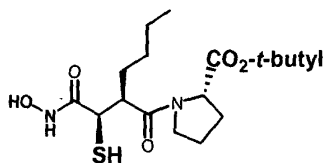
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*R*)-hydroxypropionamide



To a solution of triflic anhydride (1.2 mmol) in CH₂Cl₂ (5 ml) at -15°C was added pyridine (2.5 mmol) followed by the addition of a solution of methyl 3-(*R*)-(*n*-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl)]-2-(*S*)-hydroxypropionate (1 mmol, see Example 36 for preparation) in dichloromethane. The reaction was allowed to warm to -5°C over 1 hour, then the solution was washed with aqueous 10% citric acid, water and sodium bicarbonate solutions, then dried (Na₂SO₄) and concentrated. This residue was dissolved in toluene (10 ml) and treated with tetrabutylammonium benzoate (TBAB, 2 mmol) for 1 hour. After removal of solvent, the residue was purified on silica gel (hexanes/ethylacetate) to afford methyl 3-(*R*)-(*n*-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl)]-2-(*R*)-benzoyloxypropionate. Treatment of this intermediate with aqueous hydroxylamine/dioxane solution for 2 days, followed by purification via semi-preparative HPLC provided title compound. MS (APCI) *m/z* 359 [M+H].

Example 38

Synthesis of *N*-hydroxy-3-(*S*)-(*n*-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl)]-2-(*R*)-thiolpropionamide

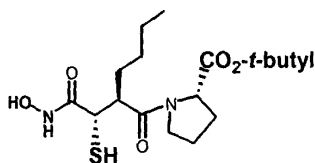


To methyl 3-(*R*)-(*n*-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl)]-2-(*S*)-hydroxypropionate (see Example 36 for preparation) in THF is added triphenylphosphine (TPP), diisopropylazodicarboxylate (DIAD) and thioacetic acid

and the solution stirred overnight. Aqueous work-up and purification on silica gel affords methyl 3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*R*)-acetylthiopropionate. This compound was dissolved in degassed dioxane and aqueous 50% hydroxylamine, then stirred for 2 d. The crude reaction mixture was purified by preparative reverse-phase (C18) HPLC to afford the title compound.

Example 39

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-thiolpropionamide



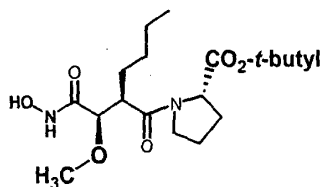
10

To a solution of triflic anhydride (Tf₂O, 1.2 mmol) in CH₂Cl₂ (5 ml) at -15°C was added pyridine (2.5 mmol) followed by the addition of a solution of methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*R*)-hydroxypropionate (1 mmol, prepared as described in Example 40, below) in DCM. The reaction was allowed to warm to -5°C over 1 hr, then the solution was washed with aqueous 10% citric acid, water, and sodium bicarbonate solution, then dried (Na₂SO₄) and concentrated. This residue was dissolved in THF (5 ml) and treated with potassium thioacetate (2 mmol) for 1 h. After removal of solvent, the residue was purified on silica gel (hexanes/ethyl acetate) to afford methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-acetylthiopropionate. Treatment of this compound with aqueous hydroxylamine/dioxane solution for 2 days, followed by purification via semi-preparative HPLC, provided the title compound. MS(APCI) m/z 375 [M+H].

20

Example 40

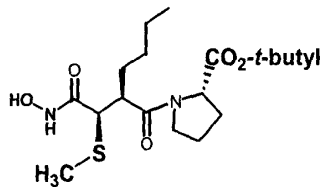
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*R*)-methoxypropionamide



5 Methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*R*)-benzoyloxypropionate (prepared as described in Example 37) was de-O-benzoylated by treatment with methanolic sodium methoxide at 0°C for 2 hours. The solution was neutralized with IR-120 (H⁺) resin, filtered, concentrated and purified on silica gel (hexanes/ethyl acetate) to afford methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*R*)-hydroxypropionate. To a
10 solution of methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*R*)-hydroxypropionate in DMF at 0°C was added sodium hydride and the reaction stirred for 1 hour. Methyl iodide was added and the reaction stirred for 1 hour at 0°C, then allowed to warm to rt and stirred an additional 2 h. Conventional
15 aqueous workup afforded the intermediate ether, which was treated with dioxane/aqueous hydroxylamine followed by purification via semi-preparative HPLC to afford the title compound. MS (APCI) m/z 373 [M+H].

Example 41

20 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*R*)-methylthiopropionamide

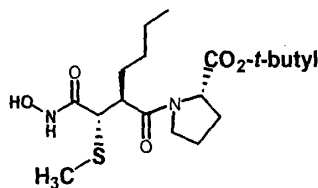


To a solution of triflic anhydride (1.2 mmol) in CH₂Cl₂ (5 ml) at -15°C is added pyridine (2.5 mmol) followed by the addition of a solution of methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*S*)-hydroxypropionate (prepared as described in Example 36 above; 1 mmol) in dichloromethane.

- 5 The solution is concentrated to dryness, dissolved in DMF and then treated with sodium thiomethoxide. Aqueous work-up followed by purification on silica gel affords methyl 3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*R*)-methylthiopropionate which is dissolved in dioxane, treated with aqueous 50% hydroxylamine, and then stirred for 2 d. The crude reaction mixture is
10 purified by preparative reverse-phase (C18) HPLC to afford title compound.

Example 42

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*S*)-methylthiopropionamide



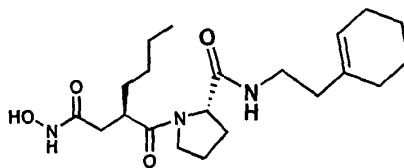
- 15 To a solution of triflic anhydride (1.2 mmol) in CH₂Cl₂ (5 ml) at -15°C is added pyridine (2.5 mmol) followed by the addition of a solution of methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*R*)-hydroxypropionate (prepared as described in Example 40; 1 mmol) in dichloromethane. The solution is concentrated to dryness, dissolved in DMF and then treated with sodium
20 thiomethoxide. Aqueous work-up followed by purification on silica gel affords methyl 3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]-2-(*S*)-methylthiopropionate which is dissolved in dioxane, treated with aqueous 50% hydroxylamine, and then stirred for 2 d. The crude reaction mixture is purified by preparative reverse-phase (C18) HPLC to afford the title compound.

25

Example 43

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(2-cyclohex-1-enylethyl)-aminocarbonyl)pyrrolidin-1-ylcarbonyl]propionamide

5



Step 1

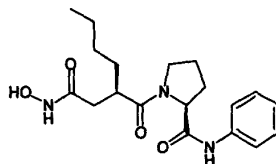
To methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-yl-carbonyl]propionate (1 mmol; prepared in one step from *mono*-4-methyl 2-(*R*)-butylsuccinic acid and L-proline *t*-butyl ester) was added 1 M HCl in dioxane (5 mL) and the solution stirred 4 h. Conventional aqueous workup afforded methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(carboxy)pyrrolidin-1-yl-carbonyl]propionate.

Step 2

To methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(carboxy)pyrrolidin-1-yl-carbonyl]propionate (0.2 mmol) in dioxane (1 mL) was added 2-(1-cyclohexenyl)-ethyl amine (0.22 mmol), DIEA (0.22 mmol) and HATU (0.22 mmol) and the reaction stirred for 2 h. Aqueous 50 % hydroxylamine was then added (1 mL), and the reaction stirred an additional 24 h. The reaction mixture was purified by preparative reverse-phase (C18) HPLC to afford the title compound. MS (APCI) *m/z* 394 [M+H].

Example 44

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[(2-(*S*)-(phenylaminocarbonyl)-pyrrolidin-1-ylcarbonyl]propionamide

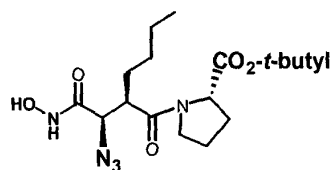


The title compound was prepared as described in Example 43, above, using aniline in place of 2-(1-cyclohexenyl)ethylamine. MS (APCI) m/z 362 [M+H].

5

Example 45

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*R*)-azidopropionamide

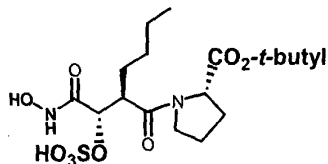


- 10 To a solution of methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionate (intermediate G-3 from General Procedure G, 2 mmol) in DCM (10 mL) was added pyridine (6 mmol), the reaction was cooled to -20°C , then triflic anhydride (4 mmol) was added. The solution was stirred for 1 hour and after the usual work-up was concentrated, resuspended in DMF
- 15 (10 mL), and treated with sodium azide (2.5 mmol). The reaction was stirred for 16 h, then diluted with ethylacetate, washed with water, saturated aqueous sodium bicarbonate, and brine, then dried (Na_2SO_4) and purified on silica gel (ethylacetate/hexanes) to afford methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*R*)-azidopropionate. To a solution of the
- 20 azido compound (0.5 mmol) in dioxane (2 mL) was added aqueous 50 % hydroxylamine (1 mL) and the reaction stirred for 48 h. The crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford the title compound. ^1H NMR(CDCl_3): δ 4.28-4.24 (dd, $J = 5.1$ & 4.6Hz , 1H), 3.92 (d, $J = 9.8$ Hz, 1H), 3.80-3.74 (m, 1H), 3.64-3.57 (m, 1H), 3.16-3.09 (m, 1H), 2.22-1.91 (m, 4H),

1.89-1.76 (m, 2H), 1.43 (s, 9H), 1.40-1.35 (m, 4H), 0.92 (t, J = 6.7 Hz). ES-MS: calcd. For C₁₇H₂₉N₅O₅ (383.3); found: 384 [M+1].

Example 46

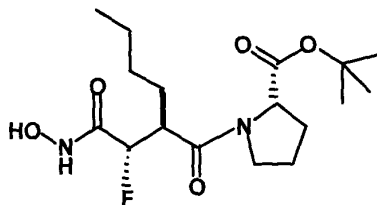
- 5 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-sulfonyloxypropionamide



- To a solution of methyl 3-(*R*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionate (intermediate **G-3** from General Procedure G, 2 mmol) in DMF (10 mL) was added pyridinium sulfurtrioxide (2.2 mmol) and the solution stirred for 1 h. The reaction was diluted with ethylacetate and washed with saline, dried (Na₂SO₄) and concentrated to afford methyl 3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*S*)-sulfonyloxypropionate.
- 15 This sulfonyloxy compound was dissolved in dioxane, treated with aqueous 50 % hydroxylamine (1 mL) and the reaction stirred for 48 h. The crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford the title compound. ¹H NMR (CDCl₃): δ 4.63 (m, 2H), 4.19-3.82 (m, 2H), 3.79-3.67 (m, 1H), 2.36-1.83 (m, 4H), 1.81-1.59 (2H), 1.45 (s, 9H), 1.34-1.26 (m, 2H), 0.89 (t, J = 6.3
- 20 Hz). ES-MS: calcd. For C₁₇H₃₀N₂O₉S (438.49); found: 439.2 [M+1].

Example 47

- 25 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



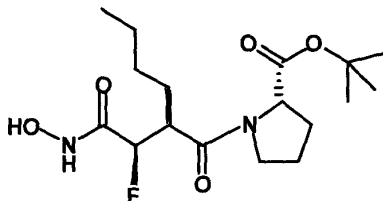
The title compound was prepared by treatment of methyl 3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-fluoropropionate

- 5 (intermediate H-4, General Procedure H), with aqueous 50 % hydroxylamine followed by purification on preparative reverse-phase (C18) HPLC. ¹H NMR (CDCl₃) δ 5.16-4.98 (dd, J_{H2,3} = 6.8 Hz & J_{H,F} = 47 Hz, 1H), 4.39-4.35 (dd, J = 4.4 & 3.8 Hz, 1H), 3.78 (m, 1H), 3.66-3.61 (m, 1H), 3.31-3.22 (m, 1H), 2.24-1.91 (m, 4H), 1.77-1.70 (m, 2H), 1.44 (s, 9H), 1.40-1.23 (m, 4H), 0.89 (t, J = 6.9 & 7.2 Hz). ES-
10 MS: calcd. For C₁₇H₂₉FN₂O₅ (360.42); found: 361 [M+1].

Example 48

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

15



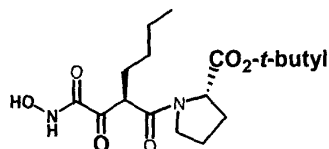
The title compound was prepared by treatment of methyl 3-(*S*)-(n-butyl)-3-[(2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*R*)-fluoropropionate

- 20 (intermediate G-4, General Procedure G), with aqueous 50 % hydroxylamine followed by purification on preparative reverse-phase (C18) HPLC. ¹H NMR (CDCl₃): δ 5.32-5.13 (dd, J_{H2,3} = 8.3 Hz & J_{H,F} = 48 Hz, 1H), 4.54-4.51 (t, J = 4.1 Hz, 1H), 3.93-3.87 (m, 1H), 3.84-3.77 (m, 1H), 3.45-3.40 (m, 1H), 2.43-2.11 (m, 4H), 2.10-1.95 (m, 2H), 1.63 (s, 9H), 1.58-1.52 (m, 4H), 1.10 (t, J = 6.6 & 7.1 Hz, 3H).
25 ES-MS: calcd. For C₁₇H₂₉FN₂O₅ (360.42); found: 361 [M+1].

Example 49

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-carbonyl]-2-oxopropionamide

5

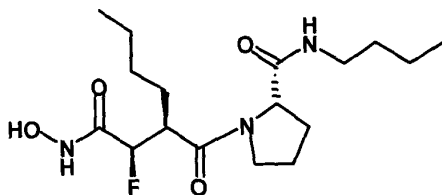


To a solution of methyl 3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionate (intermediate **G-3** from General
10 Procedure G, 2 mmol) in DCM (10 mL) at 0 °C was added pyridinium dichromate (2.2 mmol) and the solution stirred for 2h. The reaction was quenched with methanol, then diluted with ethylacetate and washed with water, aqueous bicarbonate, and brine, then dried (Na₂SO₄) and purified on silica gel (ethylacetate/hexanes) to afford methyl
15 3-(*R*)-(n-butyl)-3-[2-(*S*)-(tert-butoxycarbonyl)-pyrrolidin-1-ylcarbonyl]-2-oxopropionate. To a solution of the 2-oxo intermediate (0.5 mmol) in dioxane (2 mL) was added aqueous 50 % hydroxylamine (1 mL) and the reaction stirred for 48 h. The crude reaction mixture was then purified by preparative reverse-phase (C18) HPLC to afford the title compound. ¹H NMR (CDCl₃): δ 4.41-4.39 (dd, J = 4.4 Hz), 4.29-4.24 (m, 1H), 3.99-3.96 (m, 1H), 3.70-3.67 (m, 1H), 2.29-1.97 (m, 4H), 1.79-1.77 (m, 2H),
20 1.43 (s, 9H), 1.37-1.35 (m, 4H), 0.91 (t, J = 6.7 & 7.1 Hz, 3H). ES-MS: calcd. For C₁₇H₂₈N₂O₆ (356.41); found: 357.4 [M+1].

Example 50

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(n-butylaminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

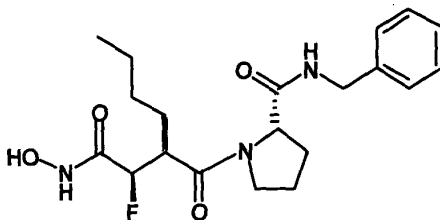
25



The title compound was prepared according to General Procedure G from *n*-butylamine. ¹H NMR (CDCl₃): δ 7.07 (t, J = 5.2 & 5.5Hz, 1H), 5.13 (dd, J_{H2,3} = 8.5 Hz & J_{H,F} = 47 Hz, 1H), 4.48-4.46 (dd, J = 4.9 Hz, 1H), 3.68-3.55 (m, 2H), 3.25-3.16 (m, 3H), 2.23-2.18 (m, 2H), 2.15-2.09 (m, 4H), 2.06-1.80 (m, 4H), 1.52-1.43 (m, 4H), 1.32 (t, J = 7.5 Hz, 3H), 0.90 (t, J = 6.6 & 7.2 Hz). ES-MS: calcd. For C₁₇H₃₀FN₃O₄ (359.44); found: 360.3 [M+1], 382.4 [M+Na].

Example 51

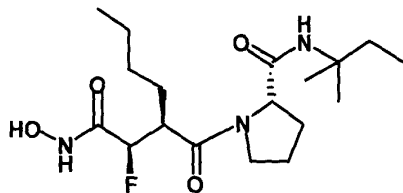
Synthesis of *N*-hydroxy-3-(*S*)-(*n*-butyl)-3-[2-(*S*)-(benzylaminocarbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



The title compound was prepared according to General Procedure G from benzylamine. ¹H NMR (CDCl₃): δ 7.47-7.40 (m, 5H), 4.66-4.60 (dd, J = 5.1 Hz & 47 Hz, 1H), 4.58-4.45 (m, 1H), 3.97-3.76 (m, 4H), 3.35-3.28 (m, 1H), 2.31-1.94 (m, 6H), 1.61-1.45 (m, 4H), 1.07 (t, J = 6.6 Hz, 3H). ES-MS: calcd. For C₁₇H₂₈FN₃O₄ (393.45); found: 394.3 [M+1], 416.2 [M+Na].

Example 52

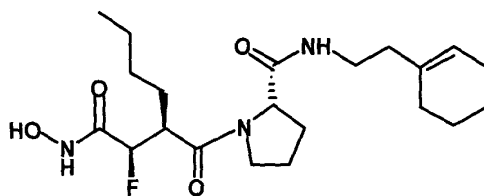
Synthesis of *N*-hydroxy-3-(*S*)-(*n*-butyl)-3-[2-(*S*)-(1,1-dimethylpropylamino)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



The title compound was prepared according to General Procedure G from 1,1-dimethylpropylamine. ¹H NMR (CDCl₃): δ 5.34-5.16 (dd, J = 7.9 & 8.3 Hz, J_{H,F} = 47 Hz), 4.61 (d, J = 4.6 Hz), 3.80-3.78 (m, 2H), 3.40-3.35 (m, 1H), 2.39-1.84 (m, 8H), 1.53-1.44 (m, 10H), 1.09 (t, J = 6.8 Hz, 3H), 1.01 (t, J = 7.7 Hz, 3H). ES-MS: calcd. For C₁₈H₃₂FN₃O₄ (373.46); found: 374.4 [M+1], 396.2 [M+Na].

Example 53

- 10 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(2-cyclohex-1-enylethylamino)-carbonyl]pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

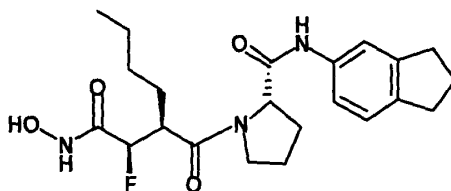


- 15 The title compound was prepared according to General Procedure G from 2-(1-cyclohexenyl)ethylamine. ¹H NMR (CDCl₃): δ 7.11 (t, J = 4.6 & 5.2 Hz, 1H), 5.62 (bs, 1H), 5.32-5.13 (dd, J = 9.3 & 9.6 Hz, J_{H,F} = 47 Hz, 1H), 4.64-4.63 (m, 1H), 3.81-3.73 (m, 2H), 3.59-3.52 (m, 1H), 3.50-3.37 (m, 3H), 2.31-2.16 (m, 9H), 2.10-1.99 (m, 2H), 1.79-1.52 (m, 9H), 1.09 (t, J = 6.5 & 5.5 Hz). ES-MS: calcd. For C₂₁H₃₄FN₃O₄ (411.51); found: 412.4[M+1], 434.5 [M+Na].
- 20

Example 54

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(indan-5-ylamino)-carbonyl]pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

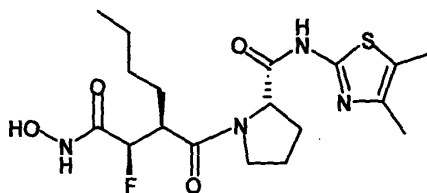
25



The title compound was prepared according to General Procedure G from 5-aminoindan. ¹H NMR (CDCl₃): δ 7.52 (s, 1H), 7.35 (d, J = 8 Hz, 1H), 7.21 (d, J = 8 Hz, 1H), 5.34-5.15 (dd, J = 8.2 & 8.5 Hz, J_{H,F} = 47 Hz, 1H), 4.86-4.84 (m, 1H), 3.80-3.78 (m, 2H), 3.36-3.31 (m, 1H), 3.06-2.96 (m, 4H), 2.41-1.97 (m, 8H), 1.58-1.48 (m, 4H), 1.04 (t, J = 6.6 & 7.2 Hz, 3H). ES-MS: calcd. For C₂₂H₃₀FN₃O₄ (419.49); found: 420.3 [M+1].

Example 55

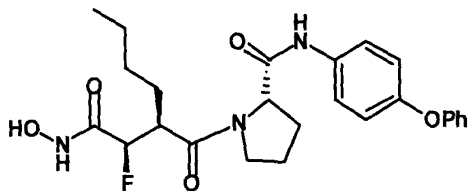
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(4,5-dimethylthiazol-2-ylamino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



The title compound was prepared according to General Procedure G from 2-amino-4,5-dimethylthiazole. ¹H NMR (CDCl₃): δ 5.32-5.13 (dd, J = 8.3 & 7.9 Hz, J_{H,F} = 47 Hz, 1H), 4.83-4.80 (m, 1H), 3.97-3.85 (m, 2H), 3.40-3.38 (m, 1H), 2.51 (s, 3H), 2.50 (s, 3H), 2.33-2.21 (m, 4H), 2.18-1.95 (m, 2H), 1.59-1.49 (m, 4H), 1.07 (t, J = 6.6 & 7.2 Hz, 3H). ES-MS: calcd. For C₁₈H₂₇FN₄O₄S (414.50); found: 415.4 [M+1], 437.3 [M+Na].

Example 56

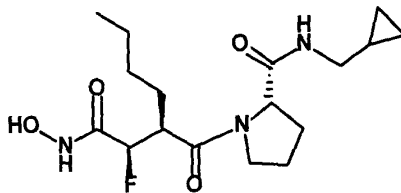
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(4-phenoxyphenyl)amino-carbonyl]pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



The title compound was prepared according to General Procedure G from 4-phenoxyaniline. ¹H NMR (CDCl₃): δ 7.69-7.16 (m, 2H), 7.53-7.46 (m, 2H), 7.29-7.24 (m, 1H), 7.18-7.06 (m, 4H), 5.37-5.20 (dd, J = 7.8 Hz, J_{H,F} = 47 Hz, 1H), 4.90-4.85 (m, 1H), 3.92-3.82 (m, 2H), 3.33-3.37 (m, 1H), 2.47-2.36 (m, 2H), 2.30-2.00 (m, 4H), 1.50-1.13 (m, 4H), 1.02 (t, J = 6.6 & 6.9 Hz, 3H). ES-MS: calcd. For C₂₅H₃₀FN₃O₅ (471.52); found: 472.4 [M+1].

Example 57

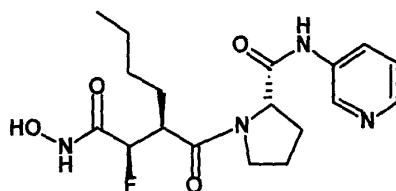
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(cyclopropylmethylamino)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



The title compound was prepared according to General Procedure G from (aminomethyl)cyclopropane. ¹H NMR (CDCl₃): δ 6.90 (t, J = 5.2 Hz, 1H), 4.99-4.82 (dd, J = 6.4 & 8 Hz, J_{H,F} = 49.8 & 48.6 Hz, 1H), 4.34-4.32 (m, 1H), 3.56-3.47 (m, 2H), 3.09-2.85 (m, 3H), 2.09-1.83 (m, 4H), 1.67-1.64 (m, 2H), 1.30-1.11 (m, 5H), 0.72 (t, J = 6.9 & 7.1 Hz, 3H), 0.33-0.29 (dd, J = 5.3 Hz, 2H), 0.05-0.00 (dd, J = 4.6 Hz, 2H). ES-MS: calcd. For C₁₇H₂₈FN₃O₄ (357.42); found: 358.4 [M+1].

Example 58

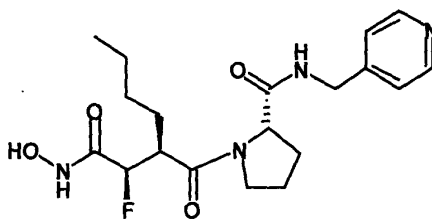
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(pyridin-3-yl)aminocarbonyl]pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



5 The title compound was prepared according to General Procedure G from 3-aminopyridine. ¹H NMR (DMSO-D₆): δ 9.15 (s, 1H), 8.62 (d, J = 4.2 Hz, 1H), 8.42 (d, J = 8.2 Hz, 1H), 7.88-7.83 (dd, J = 5.3 & 4.9 Hz, 1H), 5.09-4.91 (dd, J = 8 Hz, J_{H,F} = 48.6 Hz, 1H), 4.60-4.56 (dd, J = 4.8 Hz, 1H), 3.92-3.89 (m, 1H), 3.87-3.79 (m, 1H), 3.42-3.35 (m, 1H), 2.37-2.04 (m, 4H), 1.81-1.51 (m, 2H), 1.50-1.39 (m, 4H), 1.04 (t, J = 6.9 & 7.2 Hz, 3H). ES-MS: calcd. For C₁₈H₂₅FN₄O₄ (380.41); found: 381.3 [M+1].

Example 59

15 Synthesis of *N*-hydroxy-3-(*S*)-(*n*-butyl)-3-[2-(*S*)-((pyridin-4-ylmethyl)amino)carbonyl]pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

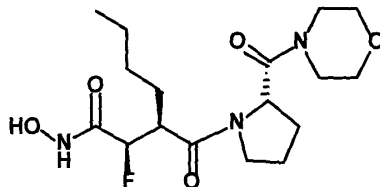


20 The title compound was prepared according to General Procedure G from 4-(aminomethyl)pyridine. ¹H NMR (DMSO-D₆): δ 8.94-8.86 (m, 3H), 7.94-7.93 (m, 1H), 5.14-4.95 (dd, J = 7.7 Hz, J_{H,F} = 48.4 Hz, 1H), 4.68-4.67 (m, 1H), 4.51-4.47 (m, 1H), 3.95-3.75 (m, 3H), 3.38-3.35 (m, 1H), 2.33-2.01 (m, 4H), 1.99-1.79 (m, 2H), 1.41-1.38 (m, 4H), 0.92 (t, J = 6.6 & 7.1 Hz, 3H). ES-MS: calcd. For C₁₉H₂₇FN₄O₄ (394.44); found: 395.4 [M+1].

Example 60

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(morpholin-4-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

5



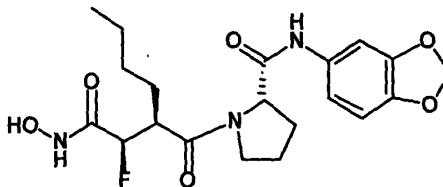
The title compound was prepared according to General Procedure G from morpholine. ¹H NMR (CDCl₃): δ 5.30-5.11 (dd, J = 8.2 Hz, J_{H,F} = 47.6 Hz, 1H), 5.06-5.04 (t, J = 3.6 & 4.4 Hz, 1H), 3.92-3.67 (m, 10H), 3.44-3.42 (m, 1H), 2.40-1.98 (m, 6H), 1.74-1.52 (m, 4H), 1.10 (t, J = 6.8 & 7.4 Hz, 3H). ES-MS: calcd. For C₁₇H₂₈FN₃O₅ (373.42); found: 374.3[M+1].

10

Example 61

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(3,4-methylenedioxyphenyl-aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

15



The title compound was prepared according to General Procedure G from 3,4-(methylenedioxy)aniline. ¹H NMR (CDCl₃): δ 7.47 (s, 1H), 7.34 (d, J = 2Hz, 1H), 6.99-6.95 (dd, J = 2Hz, 1H), 6.80 (d, J = 8.5 Hz, 1H), 6.08 (s, 2H), 5.36-5.17 (dd, J = 8.5 & 8.8 Hz, J_{H,F} = 47 Hz, 1H), 4.82-4.81 (dd, J = 4.4 Hz, 1H), 3.84-3.80 (m, 2H), 3.38-3.33 (m, 1H), 2.40-1.97 (m, 6H), 1.57-1.52 (m, 4H), 1.059 (t, J = 6.9 & 7.1 Hz, 3H). ES-MS: calcd. For C₂₀H₂₆FN₃O₆ (423.44); found: 424.3 [M+1].

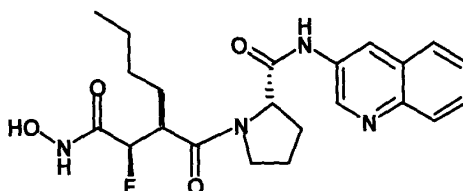
20

25

Example 62

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(quinolin-3-ylamino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

5

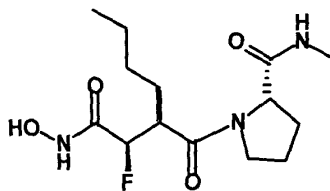


The title compound was prepared according to General Procedure G from 3-aminoquinoline. ¹H NMR (CDCl₃): δ 9.32 (s, 1H), 8.31 (d, J = 8.8 Hz, 1H), 8.03-7.81 (m, 3H), 7.48-7.46 (m, 2H), 5.35-5.17 (dd, J = 7.7 & 8 Hz, J_{H,F} = 47 Hz, 1H), 4.89-4.85 (m, 1H), 3.90-3.85 (m, 2H), 3.45-3.37 (m, 1H), 2.41-2.02 (m, 5H), 1.67-1.52 (m, 5H), 1.10 (t, J = 6.9 & 5.7 Hz, 3H). ES-MS: calcd. For C₂₂H₂₇FN₄O₄ (430.47); found: 431.3 [M+1].

15

Example 63

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(methylaminocarbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



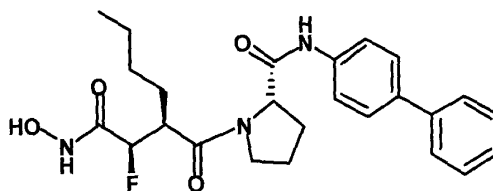
20

The title compound was prepared according to General Procedure G from methylamine. ¹H NMR (CDCl₃): δ 7.30 (d, J = 5.6 Hz, 1H), 5.30-5.12 (dd, J = 7.9 & 8.8 Hz, J_{H,F} = 47 Hz, 1H), 3.84-3.82 (m, 2H), 3.41-3.39 (m, 1H), 2.95 (s, 3H), 2.32-

1.99 (m, 6H), 1.63-1.51 (m, 4H), 1.09 (t, J = 6.4 & 4.9 Hz, 3H). ES-MS: calcd. For $C_{14}H_{24}FN_3O_4$ (317.36); found 318.3 [M+1].

Example 64

- 5 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((4-biphenyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



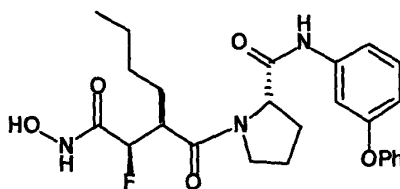
10

The title compound was prepared according to General Procedure G from 4-phenylaniline. 1H NMR ($CDCl_3$): δ 7.75-7.46 (m, 10H), 5.39-5.21 (dd, J = 8.8 Hz, $J_{H,F}$ = 47 Hz, 1H), 4.91-4.89 (m, 1H), 3.85-3.83 (m, 2H), 3.41-3.36 (m, 1H), 2.45-2.02 (m, 6H), 1.63-1.50 (m, 4H), 1.06 (t, J = 6.6 & 7.4 Hz, 3H). ES-MS: calcd. For $C_{25}H_{30}FN_3O_4$ (455.52); found 456.3 [M+1].

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Example 65

- 20 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3-phenoxyphenyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



25

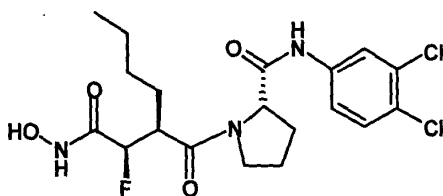
The title compound was prepared according to General Procedure G from 3-phenoxyaniline. 1H NMR ($CDCl_3$): δ 7.53-7.46 (m, 4H), 7.35-7.25 (m, 3H), 7.18-7.14 (m, 2H), 6.85-6.18 (m, 1H), 5.35-5.16 (dd, J = 8.8 Hz, $J_{H,F}$ = 47 Hz, 1H), 4.84-

4.82 (m, 1H), 3.81-3.78 (m, 2H), 3.36-3.31 (m, 1H), 2.41-1.97 (m, 6H), 1.53-1.46 (m, 4H), 1.02 (t, J = 6.6 & 7.1 Hz, 3H). ES-MS: calcd. For C₂₅H₃₀FN₃O₅ (471.52); found 472.4 [M+1].

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Example 66

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*-((3,4-dichlorophenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

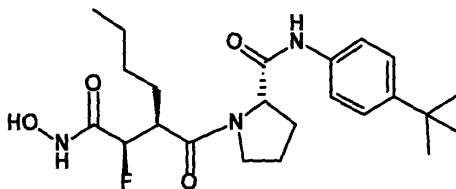


10

The title compound was prepared according to General Procedure G from 3,4-dichloroaniline. ¹H NMR (CDCl₃): δ 7.78 (s, 1H), 7.47-7.32 (m, 2H), 5.35-5.16 (dd, J = 8.8 Hz, J_{H,F} = 47 Hz, 1H) 4.82-4.80 (m, 1H), 3.85-3.79 (m, 2H), 3.36-3.31 (m, 15 1H), 2.35-2.03 (m, 6H), 1.67-1.54 (m, 4H), 1.10 (t, J = 6.6 & 6.8 Hz, 3H). ES-MS: calcd. For C₁₉H₂₄Cl₂FN₃O₄ (444.11); found: 448.2 [M+1].

Example 67

20 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*-((4-*tert*-butylphenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



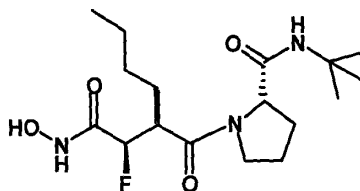
The title compound was prepared according to General Procedure G from 4-
25 *tert*-butylaniline. ¹H NMR (CDCl₃): δ 7.67(m,2H), 7.57-7.45 (m, 3H), 5.35-5.16 (dd,

J = 8.2 & 8.5 Hz, $J_{H,F}$ = 47 Hz, 1H), 4.85 (d, J = 4.4 Hz, 1H), 3.83-3.80 (m, 2H), 3.39-3.34 (m, 1H), 2.43-2.00 (m, 6H), 1.57-1.45 (m, 13H), 1.023 (t, J = 6.6 & 7.1 Hz, 3H).
ES-MS: calcd. For $C_{23}H_{34}FN_3O_4$ (435.53); found: 436.4 [M+1].

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Example 68

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(tert-butylaminocarbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



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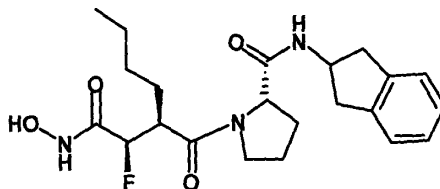
The title compound was prepared according to General Procedure G from *tert*-butylamine. 1H NMR ($CDCl_3$): δ 5.33-5.14 (dd, J = 8 Hz, $J_{H,F}$ = 48 Hz, 1H), 4.58 (d, J = 4.7 Hz, 1H), 3.81-3.79 (m, 2H), 3.42-3.39 (m, 1H), 2.40-1.98 (m, 10H), 1.55-1.49 (m, 13H), 1.11 (t, J = 5.8 & 6.6 Hz, 3H). ES-MS: calcd. For $C_{17}H_{30}FN_3O_4$ (359.44);
found: 360.3 [M+1].

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Example 69

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((indan-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

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The title compound was prepared according to General Procedure G from 2-aminoindan. 1H NMR ($CDCl_3$): δ 7.48-7.33 (m, 4H), 5.25-5.07 (dd, J = 8.5 Hz, $J_{H,F}$

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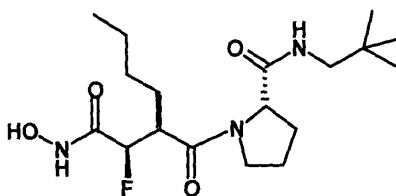
= 47.5 Hz, 1H), 4.86-4.80 (m, 1H), 4.57-4.55 (m, 1H), 3.78-3.76 (m, 2H), 3.51-3.42 (m, 2H), 3.35-3.30 (m, 1H), 3.01-2.92 (m, 2H), 2.37-2.27 (m, 2H), 2.17-1.92 (m, 2H), 1.52-1.42 (m, 4H), 1.08 (t, J = 6.8 Hz, 3H). ES-MS: calcd. For C₂₂H₃₀FN₃O₄ (419.49); found: 420.6 [M+1].

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Example 70

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((2,2-dimethylpropyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

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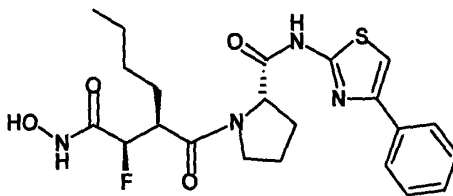


The title compound was prepared according to General Procedure G from 2,2-dimethylpropylamine. ¹H NMR (CDCl₃): δ 7.28 (t, J = 6 Hz, 1H), 5.36-5.18 (dd, J = 8.4 Hz, J_{H,F} = 47.5 Hz, 1H), 4.75 (d, J = 5.2 Hz, 1H), 3.85-3.77 (m, 2H), 3.40-3.35 (m, 1H), 3.29-3.19 (m, 2H), 2.50-2.27 (m, 2H), 2.17-2.13 (m, 2H), 2.09-1.98 (m, 2H), 1.53-1.51 (m, 4H), 1.08 (bs, 3H). C₁₈H₃₂FN₃O₄ (373.24); found: 374.4 [M+1].

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Example 71

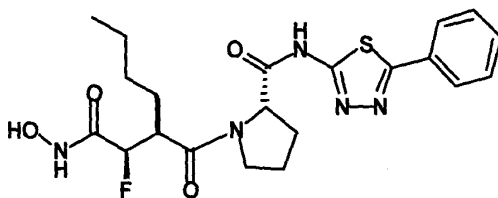
20 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((4-phenylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



The title compound was prepared according to General Procedure G from 2-amino-4-phenylthiazole. ¹H NMR (CDCl₃): δ 7.92–7.90 (m, 2H), 7.71 (m, 3H), 7.46 (s, 1H), 7.28 (s, 1H), 5.37 – 5.18 (dd, J = 8.5 & 8.2 Hz, J_{H,F} = 47 Hz, 1H), 4.95–4.93 (m, 1H), 3.99–3.95 (m, 2H), 3.43–3.38 (m, 1H), 2.54–2.26 (m, 4H), 2.21–1.96 (m, 2H), 1.62–1.50 (m, 4H), 1.08 (t, J = 6.9 & 7.1 Hz, 3H). ES-MS: calcd. For C₂₂H₂₇FN₄O₄S (462.54); found: 463.4 [M+1].

Example 72

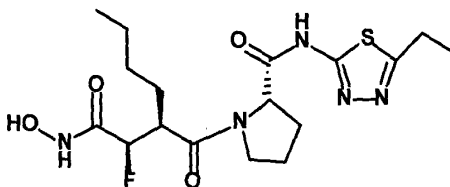
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((5-phenylthiadiazol-2-yl)amino)carbonyl]pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



The title compound was prepared according to General Procedure G from 2-amino-5-phenylthiadiazole. ¹H NMR (CDCl₃): δ 8.08–8.05 (m, 2H), 7.68–7.48 (m, 3H), 5.45–5.26 (dd, J = 9.2 Hz, J_{H,F} = 47 Hz, 1H), 4.99–4.97 (m, 1H), 3.96–3.94 (m, 2H), 3.38–3.36 (m, 1H), 2.50–1.98 (m, 6H), 1.61–1.51 (m, 4H), 1.09 (t, J = 6.9 Hz, 3H). ES-MS: calcd. For C₂₁H₂₆FN₅O₄S (463.53); found: 464.2 [M+1].

Example 73

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((5-ethylthiadiazol-2-yl)amino)carbonyl]pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



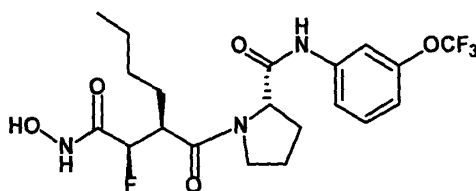
The title compound was prepared according to General Procedure G from 2-amino-5-ethylthiadiazole. ¹H NMR (CDCl₃): δ 5.43–5.24 (dd, J = 9.6 Hz, J_{H,F} = 47.5

Hz, 1H), 5.00–4.98 (m, 1H), 3.97–3.88 (m, 1H), 3.38–3.36 (m, 2H), 3.27–3.20 (m, 2H), 2.47–2.21 (m, 4H), 2.19–1.97 (m, 2H), 1.58 (t, $J = 7.7$ Hz, 3H), 1.58–1.49 (m, 4H), 1.09 (t, $J = 6.8$ & 7.2 Hz, 3H). ES-MS: calcd. For $C_{17}H_{26}FN_5O_4S$ (415.48); found: 416.2 $[M+1]$.

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Example 74

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3-trifluoromethoxyphenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



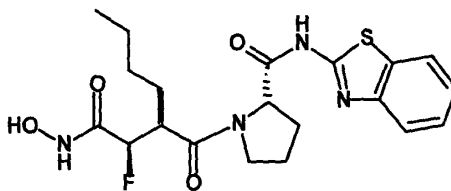
10

The title compound was prepared according to General Procedure G from 3-(trifluoromethoxy)aniline. 1H NMR ($CDCl_3$): δ 7.71 (s, 1H), 7.48–7.41 (m, 2H), 7.29 (t, $J = 8.2$ Hz, 1H), 6.98 (d, $J = 7.9$ Hz, 1H), 5.39–5.21 (dd, $J = 9.3$ & 8.8 Hz, 1H), 4.88–4.86 (m, 1H), 3.85–3.82 (m, 2H), 3.39–3.37 (m, 1H), 2.41–2.04 (m, 6H), 1.61–1.53 (m, 4H), 1.06 (t, $J = 6.9$ Hz, 3H). ES-MS: calcd. For $C_{20}H_{25}F_4N_3O_5$ (463.42); found: 454.2 $[M + 1]$.

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Example 75

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((benzthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



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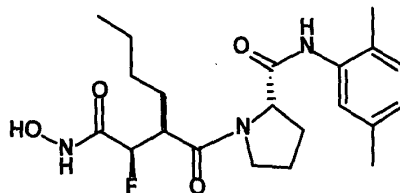
The title compound was prepared according to General Procedure G from 2-aminobenzothiazole. 1H NMR ($CDCl_3$): δ 7.99–7.92 (dd, $J = 7.5$ & 8.2 Hz, 2H), 7.70–7.64 (dd, $J = 8$ & 7.6 Hz, 1H), 7.56 (t, $J = 7.9$ & 8.5 Hz, 1H), 5.43–5.24 (dd, $J =$

8.2 & 8.5 Hz, $J_{H,F} = 47$ Hz, 1H), 5.04 – 5.01 (m, 1H), 4.00–3.97 (m, 2H), 3.47–3.42 (m, 1H), 2.57–2.21 (m, 4H), 2.00 – 1.97 (m, 2H), 1.64–1.52 (m, 4H), 1.09 (t, $J = 6.8$ & 7.2 Hz, 3H). ES-MS: calcd. For $C_{20}H_{25}FN_4O_4S$ (436.50); found: 437.3 [M+1].

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Example 76

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((2,5-dimethylphenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide



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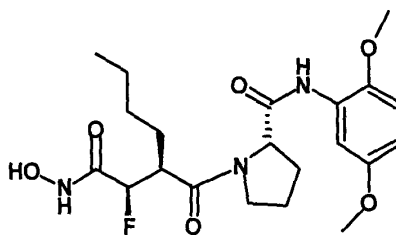
The title compound was prepared according to General Procedure G from 2,5-dimethylaniline. 1H NMR ($CDCl_3$): δ 7.81 (s, 1H), 7.22 (d, $J = 7.7$ Hz, 1H), 7.05 (d, $J = 7.9$ Hz, 1H), 5.42–5.23 (dd, $J = 8.5$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.99–4.97 (m, 1H), 3.83–3.79 (m, 2H), 3.40–3.35 (m, 1H), 2.66–2.63 (m, 2H), 2.47 (s, 3H), 2.38 (s, 3H), 2.24–2.19 (m, 2H), 2.18–1.99 (m, 2H), 1.64–1.46 (m, 4H), 0.99 (t, $J = 6.6$ & 6.9 Hz, 3H). ES-MS: calcd. For $C_{21}H_{30}FN_3O_4$ (407.48); found: 408.3 [M+1].

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Example 77

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((2,5-dimethoxyphenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*R*)-fluoropropionamide

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The title compound was prepared according to General Procedure G from 2,5-dimethoxyaniline. 1H NMR ($CDCl_3$): δ 8.22 (d, $J = 3$ Hz, 1H), 6.96 (d, $J = 8.8$ Hz, 1H), 6.79 – 6.75 (dd, $J = 3$ Hz, 1H), 5.41–5.22 (dd, $J = 8$ Hz; $J_{H,F} = 47$ Hz, 1H), 4.92–

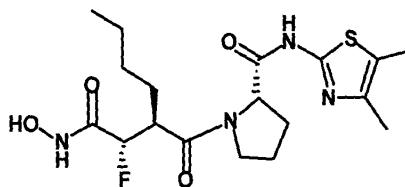
25

4.90 (m, 1H), 4.00 (s, 3H), 3.96 (s, 3H), 3.95–3.85 (m, 2H), 3.45–3.39 (m, 1H), 2.56–2.23 (m, 4H), 2.02–1.99 (m, 2H), 1.64–1.49 (m, 4H), 1.00 (t, $J = 6.3$ & 7.1 Hz, 3H).
ES-MS: calcd. For $C_{21}H_{30}FN_3O_6$ (439.48); found: 440.4 $[M + 1]$.

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Example 78

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((4,5-dimethylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



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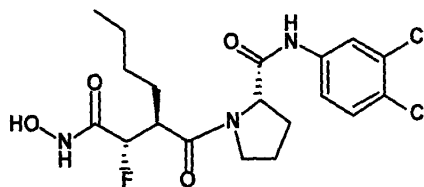
The title compound was prepared according to General Procedure H from 2-amino-4,5-dimethylthiazole. 1H NMR ($CDCl_3$): δ 5.32–5.14 (dd, $J = 5.7$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.85 – 4.81 (dd, $J = 6$ & 5.3 Hz, 1H), 4.03–3.99 (m, 2H), 3.53–3.43 (m, 1H), 2.52 (s, 3H), 2.50 (s, 3H), 2.36–2.22 (m, 4H), 2.19–1.79 (m, 2H), 1.60–1.50 (m, 4H), 1.08 (t, $J = 6.6$ & 6.9 Hz, 3H). ES-MS: calcd. For $C_{18}H_{27}FN_4O_4S$ (414.50); found: 415.4 $[M + 1]$.

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Example 79

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3,4-dichlorophenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

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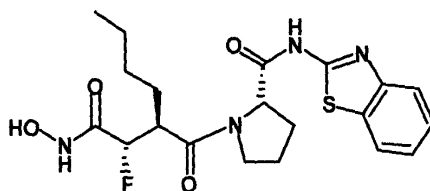
The title compound was prepared according to General Procedure H from 3,4-dichloroaniline. 1H NMR ($CDCl_3$): δ 7.94 (s, 1H), 7.48–7.46 (m, 2H), 5.38–5.21 (dd, $J = 4.4$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.73–4.71 (m, 1H), 3.92–3.91 (m, 2H), 3.53–3.52 (m,

25

1H), 2.53–1.97 (m, 6H), 1.59–1.58 (m, 4H), 1.09 (t, J = 6.9 Hz, 3H). ES-MS: calcd. For C₁₉H₂₄Cl₂FN₃O₄S (447.11); found: 448.2 [M+1].

Example 80

5 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((benzthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



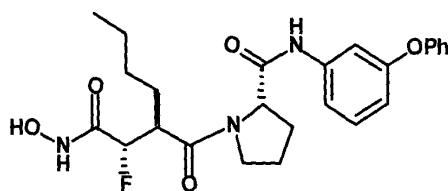
10

The title compound was prepared according to General Procedure H from 2-aminobenzothiazole. ¹H NMR (CDCl₃): δ 7.66 (t, J = 7.7 Hz, 2H), 7.34 (t, J = 6.9 & 7.9 Hz, 1H), 7.26 (t, J = 7.7 & 7.4 Hz, 1H), 5.10–5.92 (dd, J = 5.8 Hz; J_{H,F} = 47 Hz, 1H), 4.75–4.73 (m, 1H), 3.75–3.70 (m, 2H), 3.30–3.21 (m, 1H), 2.24–1.97 (m, 4H), 1.70–1.56 (m, 2H), 1.33–1.25 (m, 4H), 0.78 (t, J = 6.8 Hz, 3H). ES-MS: calcd. For C₂₀H₂₅F N₄O₄S (436.50); found: 437.3 [M + 1].

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Example 81

20 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3-phenoxyphenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



The title compound was prepared according to General Procedure H from 3-phenoxyaniline. ¹H NMR (CDCl₃): δ 7.62–7.51 (m, 5H), 7.50–7.43 (m, 1H), 7.42–7.30 (m, 1H), 7.28–7.16 (m, 2H), 6.90–6.86 (m, 1H), 5.32–5.14 (dd, J = 5.3 Hz, J_{H,F} =

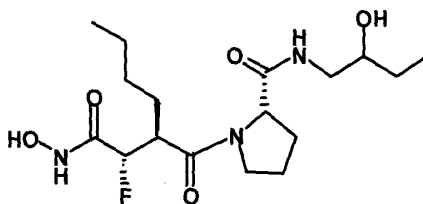
25

47 Hz, 1H), 4.76–4.74 (m, 1H), 3.89–3.87 (m, 2H), 3.51–3.41 (m, 1H), 2.47–1.92 (m, 6H), 1.53–1.51 (m, 4H), 1.05 (t, $J = 6.9$ & 7.1 Hz, 3H). ES-MS: calcd. For $C_{25}H_{30}FN_3O_5$ (471.52); found: 472.4 $[M+1]$.

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Example 82

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((2-(*RS*)-hydroxybutyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



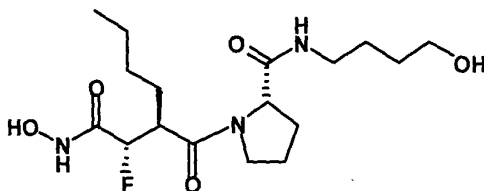
10

The title compound was prepared according to General Procedure H from (\pm)-2-hydroxy-*n*-butylamine. 1H NMR (CD_3OD): δ 5.09–4.92 (dd, $J = 8.8$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.63–4.59 (m, 1H), 4.03–3.90 (m, 1H), 3.88–3.79 (m, 1H), 3.76–3.73 (m, 1H), 3.51 (s, 2H), 3.46–3.23 (m, 1H), 2.41–2.14 (m, 4H), 1.79–1.52 (m, 8H), 1.17 (t, $J = 7.3$ Hz, 3H), 1.11 (t, $J = 6$ & 7.4 Hz, 3H). ES-MS: calcd. For $C_{17}H_{30}FN_3O_5$ (375.44); found: 376.4 $[M+1]$.

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Example 83

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((4-hydroxybutyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



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The title compound was prepared according to General Procedure H from 4-aminobutanol. 1H NMR (CD_3OD): δ 5.07–4.90 (dd, $J = 8.8$ Hz, $J_{H,F} = 47$ Hz, 1H),

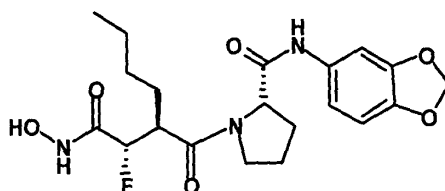
4.60–4.55 (dd, $J = 4.5$ & 4.9 Hz, 1H), 4.05–3.92 (m, 1H), 3.90–3.81 (m, 1H), 3.76 (s, 2H), 3.51 (s, 2H), 3.44–3.38 (m, 1H), 2.44–2.10 (m, 6H), 1.86–1.63 (m, 4H), 1.60–1.52 (m, 2H), 1.14 (t, $J = 6.8$ Hz, 3H). ES-MS: calcd. For $C_{17}H_{30}FN_3O_5$ (375.44); found: 376.4 [M+1].

5

Example 84

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3,4-methylenedioxyphenyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

10

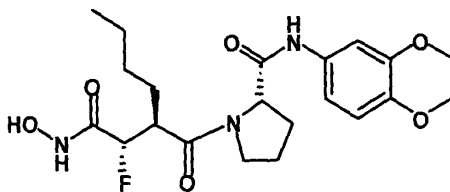


The title compound was prepared according to General Procedure H from 3,4-(methylenedioxy)aniline. ^1H NMR (CDCl_3): 7.19 (s, 1H), 6.86 (d, $J = 8$ Hz, 1H), 6.67 (d, $J = 8$ Hz, 1H), 5.89 (s, 2H), 5.13–4.96 (dd, $J = 4.4$ Hz, $J_{\text{H,F}} = 47$ Hz, 1H), 4.55–4.53 (m, 1H), 3.76–3.72 (m, 2H), 3.30–3.21 (dd, $J = 4.1$ Hz, 1H), 2.26–2.24 (m, 2H), 2.01–1.95 (m, 2H), 1.73 (bs, 2H), 1.32 (bs, 4H), 0.86 (t, $J = 6.3$ Hz, 3H). ES-MS: calcd. For $C_{20}H_{26}FN_3O_6$ (423.44); found: 424.3 [M+1].

20

Example 85

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((1,4-benzodioxan-6-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

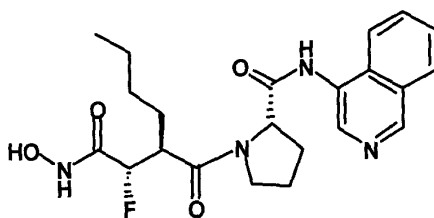


25

The title compound was prepared according to General Procedure H from 1,4-benzodioxan-6-amine. ¹H NMR (CDCl₃): δ 7.14 (s, 1H), 6.93 (d, J = 8.5 Hz, 1H), 6.74, (d, J = 8.5 Hz, 1H), 5.14–4.97 (dd, J = 4.5 Hz, J_{H,F} = 47 Hz, 1H), 4.58–4.56 (m, 1H), 4.20 (s, 4H), 3.73–3.64 (m, 2H), 3.49–3.21 (m, 1H), 2.30–2.27 (m, 2H), 2.01–1.94 (m, 2H), 1.74 (bs, 2H), 1.32 (bs, 4H), 0.85 (t, J = 6.6 & 7.1 Hz, 3H). ES-MS: calcd. For C₂₁H₂₈FN₃O₆ (437.46); found: 438.3 [M+1].

Example 86

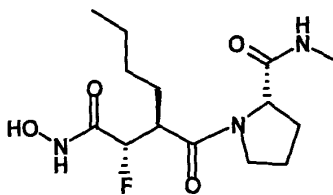
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((isoquinolin-3-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



The title compound was prepared according to General Procedure H from 6-aminoisoquinoline. ¹H NMR (CDCl₃): δ 9.89 (s, 1H), 9.63 (s, 1H), 7.85 (d, J = 8.5 Hz, 1H), 7.71 (m, 2H), 7.61 (d, J = 8.5 Hz, 1H), 5.16–4.99 (dd, J = 5.8 Hz, J_{H,F} = 47 Hz, 1H), 4.76–4.73 (m, 1H), 3.85 (m, 2H), 3.41–3.25 (m, 1H), 2.35–1.99 (m, 4H), 1.33–1.25 (m, 6H), 0.85 (t, J = 6.8 & 7.1 Hz, 3H). ES-MS: calcd. For C₂₂H₂₇FN₄O₄ (430.47); found: 431.3 [M+1].

Example 87

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(methylaminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



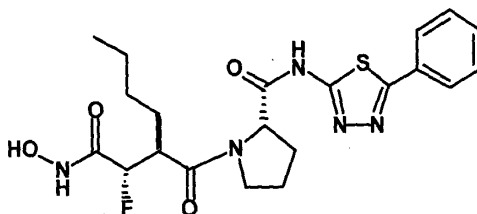
The title compound was prepared according to General Procedure H from methylamine. ¹H NMR (CD₃OD): δ 5.064.90 (dd, J = 8.7 Hz, J_{H,F} = 47 Hz, 1H), 4.58–4.54 (dd, J = 5 Hz, 1H), 4.05–4.00 (m, 1H), 3.99–3.82 (m, 1H), 3.50–3.49 (m, 1H), 2.93 (s, 3H), 2.40–2.08 (m, 4H), 1.79–1.51 (m, 6H), 1.21 (t, J = 6.8 Hz, 3H).

5 ES-MS: calcd. For C₁₄H₂₄FN₃O₄ (317.36); found: 318.3 [M+1].

Example 88

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((5-phenylthiadiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

10



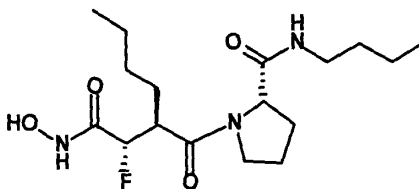
The title compound was prepared according to General Procedure H from 2-amino-5-phenylthiadiazole. ¹H NMR (CDCl₃ + DMSO-D₆): δ 7.47–7.34 (m, 5H), 5.06–5.03 (dd, J = 7.7 Hz, J_{H,F} = 47 Hz, 1H), 5.02–4.87 (m, 1H), 3.80–3.71 (m, 2H), 3.31–3.28 (m, 1H), 2.18–2.12 (m, 4H), 1.73–1.33 (m, 6H), 0.87 (t, J = 6.7 Hz, 3H). ES-MS: calcd. For C₂₁H₂₆FN₅O₄S (463.53); found: 464.2 [M+1].

15

Example 89

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(n-butylaminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

20

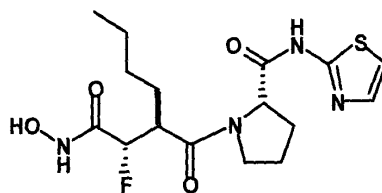


25

The title compound was prepared according to General Procedure H from *n*-butylamine. ¹H NMR (CDCl₃): δ 7.21 (t, J = 6.5 & 5.5 Hz, 1H), 5.14–4.97 (dd, J = 5.8 Hz, J_{H,F} = 47 Hz, 1H), 3.65–3.57 (m, 2H), 3.30–3.16 (m, 3H), 2.23–2.17 (m, 2H), 1.97–1.72 (m, 2H), 1.69–1.50 (m, 2H), 1.48–1.25 (m, 8H), 0.92–0.87 (m, 6H). ES-MS: calcd. For C₁₇H₃₀FN₃O₄ (359.44); found: 360.3 [M+1].

Example 90

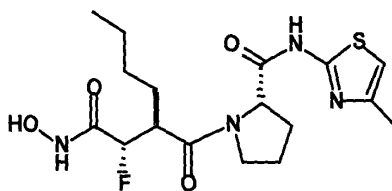
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((thiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



The title compound was prepared according to General Procedure H from 2-aminothiazole. ¹H NMR (CDCl₃ + DMSO-D₆): δ 7.40 (d, J = 3.6 Hz, 1H), 6.95 (d, J = 3.6 Hz, 1H), 5.05–4.88 (dd, J = 7.4 Hz, J_{H,F} = 47 Hz, 1H), 4.86–4.84 (m, 1H), 3.84–3.71 (m, 2H), 3.33–3.23 (m, 1H), 2.16–1.99 (m, 4H), 1.72–1.30 (m, 6H), 0.84 9 (t, J = 6.8 & 7.1 Hz, 3H). ES-MS: calcd. For C₁₆H₂₃FN₄O₄S (386.44); found: 387.4 [M+1].

Example 91

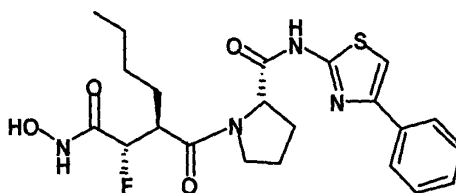
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((4-methylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



The title compound was prepared according to General Procedure H from 2-amino-4-methylthiazole. ¹H NMR (CDCl₃ + DMSO-D₆): δ 6.49 (s, 1H), 5.10–4.92 (dd, J = 6.6 Hz, J_{H,F} = 47 Hz, 1H), 4.85–4.83 (m, 1H), 3.79–3.68 (m, 2H), 3.37–3.23 (m, 1H), 2.31 (s, 3H), 2.22–1.99 (m, 4H), 1.74–1.52 (m, 2H), 1.29–1.27 (m, 4H), 0.83 (t, J = 6.6 & 7.1 Hz, 3H). ES-MS: calcd. For C₁₇H₂₅FN₄O₄S (400.47); found: 401.6 [M+1].

Example 92

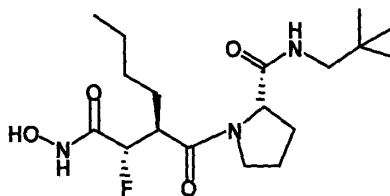
10 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((4-phenylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



15 The title compound was prepared according to General Procedure H from 2-amino-4-phenylthiazole. ¹H NMR (CDCl₃): δ 7.38–7.26 (m, 5H), 6.95 (s, 1H), 5.15–5.01 (dd, J = 4.2 Hz, J_{H,F} = 47Hz, 1H), 4.99–4.83 (m, 1H), 3.76–3.70 (m, 2H), 3.31–3.27 (m, 1H), 2.15–1.99 (m, 4H), 1.72–1.50 (m, 2H), 1.44–1.25 (m, 4H), 0.81 (t, J = 6.6 & 7.1 Hz, 3H). ES-MS: calcd. For C₂₂H₂₇FN₄O₄S (462.54); found: 463.5 [M+1].

Example 93

20 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((2,2-dimethylpropyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

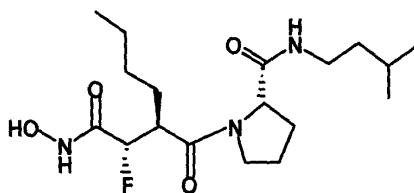


25

The title compound was prepared according to General Procedure H from 2,2-dimethylpropylamine. ¹H NMR (CDCl₃): δ 7.16 (t, J = 6 Hz, 1H), 5.14–4.96 (dd, J = 6.1 Hz, J_{H,F} = 47 Hz, 1H), 4.55–4.48 (m, 1H), 3.69–3.61 (m, 2H), 3.31–3.22 (m, 1H), 3.14–3.07 (m, 1H), 2.98–2.91 (m, 1H), 2.24–1.96 (m, 4H), 1.72–1.63 (m, 2H), 1.33–1.30 (m, 4H), 0.88 (m, 12H). ES-MS: calcd. For C₁₈H₃₂FN₃O₄ (373.46); found: 374.7 [M+1].

Example 94

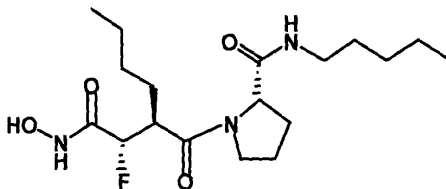
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3-methylbutyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



The title compound was prepared according to General Procedure H from 3-methylbutylamine. ¹H NMR (CDCl₃): δ 7.17 (t, J = 5.2 Hz, 1H), 5.13–4.95 (dd, J = 6.1 Hz, J_{H,F} = 47 Hz, 1H), 4.47–4.44 (m, 1H), 3.66–3.57 (m, 2H), 3.31–3.17 (m, 3H), 2.23–2.17 (m, 2H), 1.96–1.91 (m, 2H), 1.74–1.54 (m, 3H), 1.42–1.32 (m, 6H), 0.91–0.87 (m, 9H). ES-MS: calcd. For C₁₈H₃₂FN₃O₄ (373.46); found: 374.7 [M+1].

Example 95

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((n-pentyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



The title compound was prepared according to General Procedure H from amylamine. ¹H NMR (CDCl₃): δ 7.18 (t, J = 5.2 Hz, 1H), 5.13–4.95 (dd, J = 6 Hz,

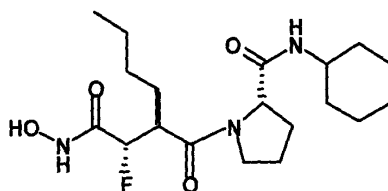
$J_{H,F} = 47$ Hz, 1H), 4.47–4.45 (m, 1H), 3.66–3.64 (m, 2H), 3.31–3.14 (m, 3H), 2.23–2.17 (m, 2H), 1.96–1.93 (m, 2H), 1.76–1.63 (m, 2H), 1.52–1.42 (m, 3H), 1.34–1.26 (m, 8H), 0.91–0.85 (m, 6H). ES-MS: calcd. For $C_{18}H_{32}FN_3O_4$ (373.46); found: 374.7 [M+1].

5

Example 96

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((cyclohexyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

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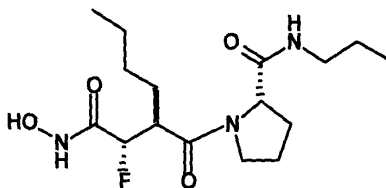
The title compound was prepared according to General Procedure H from cyclohexylamine. 1H NMR ($CDCl_3$): δ 7.00 (d, $J = 8.2$ Hz, 1H), 5.14–4.96 (dd, $J = 6.2$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.46–4.44 (m, 1H), 3.73–3.59 (m, 3H), 3.31–3.22 (m, 1H), 2.19–2.10 (m, 4H), 1.96–1.64 (m, 6H), 1.33–1.27 (m, 6H), 1.20–1.12 (m, 4H), 0.89 (t, $J = 6.6$ Hz, 3H). ES-MS: calcd. For $C_{19}H_{32}FN_3O_4$ (385.47); found: 386.7 [M+1].

15

Example 97

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((n-propyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

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25

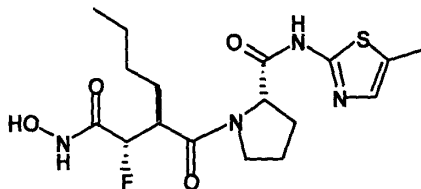
The title compound was prepared according to General Procedure H from propylamine. 1H NMR ($CDCl_3 + DMSO-D_6$): δ 7.24 (t, $J = 5.2$ Hz, 1H), 4.99–4.80

(dd, $J = 8.8$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.59–4.57 (m, 1H), 3.72–3.56 (m, 2H), 3.37–3.12 (m, 3H), 2.31–2.26 (m, 2H), 2.09–1.84 (m, 4H), 1.66–1.43 (m, 2H), 1.28–1.03 (m, 4H), 0.91–0.87 (m, 6H). ES-MS: calcd. For $C_{16}H_{28}FN_3O_4$ (345.41); found: 346.6 [M+1].

5

Example 98

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((5-methylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



10

The title compound was prepared according to General Procedure H from 2-amino-5-methylthiazole. 1H NMR ($CDCl_3$): δ 7.31 (s, 1H), 5.32–5.14 (dd, $J = 6.1$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.8–4.83 (m, 1H), 4.03–3.94 (m, 2H), 3.53–3.44 (m, 1H), 2.62 (s, 3H), 2.58–2.21 (m, 4H), 1.99–1.78 (m, 2H), 1.54–1.45 (m, 4H), 1.08 (t, $J = 6.6$ &

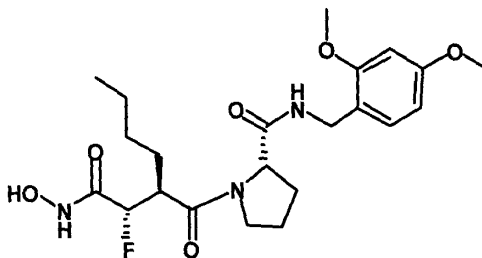
15

7.4 Hz, 3H). ES-MS: calcd. For $C_{17}H_{25}FN_4O_4S$ (400.47); found: 401.6 [M+1].

Example 99

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3,4-dimethoxybenzyl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

20



25

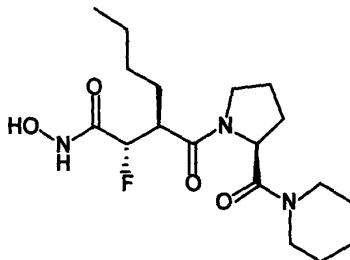
The title compound was prepared according to General Procedure H from 2,4-dimethoxybenzylamine. 1H NMR ($CDCl_3$): δ 7.31 (d, $J = 8$ Hz, 1H), 6.67–6.58 (m, 2H), 5.30–5.14 (dd, $J = 2$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.67–4.45 (m, 3H), 4.00 (s, 3H), 3.98

(s, 3H), 3.86–3.78 (m, 2H), 3.45–3.39 (m, 1H), 2.37–2.13 (m, 4H), 1.89–1.84 (m, 2H), 1.47–1.45 (m, 4H), 1.04 (t, $J = 6.3$ & 7.1 Hz, 3H). ES-MS: calcd. For $C_{22}H_{32}FN_3O_6$ (453.51); found: 454.8 $[M+1]$.

5

Example 100

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(piperidin-1-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



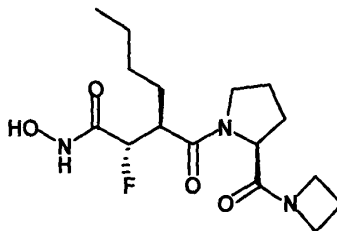
10

The title compound was prepared according to General Procedure H from piperidine. 1H NMR ($CDCl_3$): δ 5.14–4.97 (dd, $J = 6.5$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.91–4.87 (m, 1H), 3.80–3.47 (m, 6H), 3.39–3.21 (m, 1H), 2.22–1.83 (m, 3H), 1.65–1.27 (m, 13H), 0.90 (t, $J = 7$ Hz, 3H). ES-MS: calcd. For $C_{18}H_{30}FN_3O_4$ (371.45); found: 372.4 $[M+1]$.

15

Example 101

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(azetidin-1-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



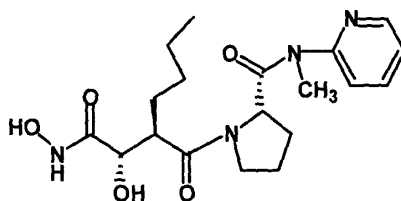
20

The title compound was prepared according to General Procedure H from azetidine. 1H NMR (CD_3OD): δ 5.10–4.92 (dd, $J = 8.7$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.73–4.65 (m, 1H), 4.60–4.57 (m, 1H), 4.49–4.41 (m, 1H), 4.32–4.21 (m, 1H), 4.18–4.12 (m, 1H), 4.06–3.99 (m, 1H), 3.89–3.81 (m, 1H), 2.59–2.41 (m, 2H), 2.41–2.30 (m, 2H),

2.28-2.05 (m, 2H), 1.84-1.49 (m, 6H), 1.11 (t, J = 7 Hz, 3H). ES-MS: calcd. For $C_{16}H_{26}FN_3O_4$ (343.39); found: 344.4 [M+1].

Example 102

- 5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((*N*-pyridin-2-yl)methylamino-carbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

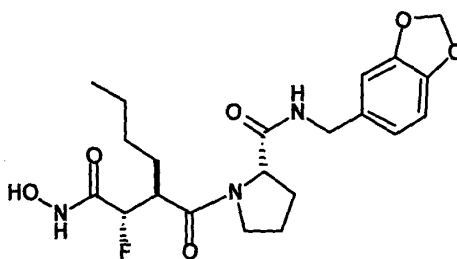


- 10 The title compound was prepared according to General Procedure F from *N*-methyl-2-amino pyridine. 1H NMR ($CDCl_3$): δ 8.75-8.04 (m, 2H), 7.71-7.46 (m, 2H), 4.76 bs, 1H), 4.46 (bs, 1H), 3.93-3.63 (m, 2H), 3.56 (s, 3H), 3.42-3.39 (m, 1H), 2.28-2.00 (m, 6H), 1.66-1.62 (m, 4H), 1.13 (t, J = 7 Hz, 3H). ES-MS: calcd. For $C_{19}H_{28}N_4O_5$ (392.45); found: 393.6 [M+1].

15

Example 103

- Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((3,4-methylenedioxybenzyl)-aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



20

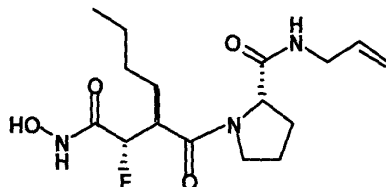
- The title compound was prepared according to General Procedure H from piperonylamine. 1H NMR ($CDCl_3$): 7.63(s, 1H), 6.93 (d, J = 9.9 Hz, 2H), 6.11 (s, 2H), 5.30-5.13 (dd, J = 5.5 Hz, $J_{H,F}$ = 47 Hz, 1H), 4.62-4.39 (m, 3H), 3.97-3.71 (m, 2H), 3.48-3.39 (m, 1H), 2.38-2.13 (m, 4H), 1.87-1.85 (m, 2H), 1.49-1.48 (m, 4H),
- 25

1.05 (t, J = 6.3 Hz, 3H). ES-MS: calcd. For C₂₁H₂₈FN₃O₆ (437.46); found: 438.7 [M+1].

5

Example 104

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((allyl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



10

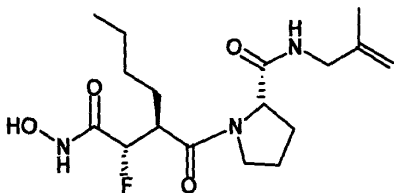
The title compound was prepared according to General Procedure H from allylamine. ¹H NMR (CDCl₃): δ 6.06–5.95 (m, 1H), 5.39–5.17 (m, 3H), 4.69–4.67 (m, 1H), 4.05–3.85 (m, 4H), 3.51–3.44 (m, 1H), 2.40–2.17 (m, 4H), 1.91–1.89 (m, 2H), 1.62–1.53 (m, 4H), 1.09 (t, J = 6.3 Hz, 3H). ES-MS: calcd. For C₁₆H₂₆FN₃O₄ (343.39); found: 344.7 [M+1].

15

Example 105

Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((2-methylallyl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

20



The title compound was prepared according to General Procedure H from 2-methylallylamine. ¹H NMR (CDCl₃): δ 5.34–5.16 (dd, J = 5.8 Hz, J_{H,F} = 47 Hz, 1H), 5.00 (s, 2H) 4.73–4.66 (m, 1H), 4.05–3.87 (m, 4H), 3.51–3.43 (m, 1H), 2.43–2.17 (m,

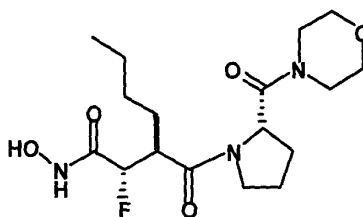
25

4H), 1.90 (s, 3H), 1.86–1.84 (m, 2H), 1.66–1.53 (m, 4H), 1.08 (t, $J = 6.6$ Hz, 3H).

ES-MS: calcd. For $C_{17}H_{28}FN_3O_4$ (357.42); found: 358.6 $[M+1]$.

Example 106

- 5 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(morpholin-4-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide

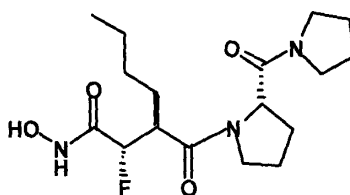


- 10 The title compound was prepared according to General Procedure H from morpholine. 1H NMR ($CDCl_3$): δ 5.34–5.16 (dd, $J = 6.2$ Hz, $J_{H,F} = 47$ Hz, 1H), 5.08–5.05 (m, 1H), 4.00–3.71 (m, 10H), 3.68–3.43 (m, 1H), 2.42–1.83 (m, 6H), 1.78–1.50 (m, 4H), 1.10 (t, $J = 6.6$ & 7.1 Hz, 3H). ES-MS: calcd. For $C_{17}H_{28}FN_3O_5$ (373.42); found: 374.5 $[M+1]$.

15

Example 107

- 15 Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-(pyrrolidin-1-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-fluoropropionamide



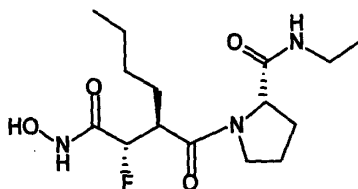
20

- 20 The title compound was prepared according to General Procedure H from pyrrolidine. 1H NMR ($CDCl_3$): δ 5.34–5.17 (dd, $J = 6.5$ Hz, $J_{H,F} = 47$ Hz, 1H), 4.86–4.82 (m, 1H), 3.94–3.89 (m, 4H), 3.77–3.71 (m, 1H), 3.64–3.42 (m, 2H), 2.38–2.20 (m, 2H), 2.18–1.74 (m, 8H), 1.65–1.48 (m, 4H), 1.10 (t, $J = 6.9$ & 7.2 Hz, 3H). ES-MS: calcd. For $C_{17}H_{28}FN_3O_4$ (357.42); found: 358.5 $[M+1]$.

25

[illegible]

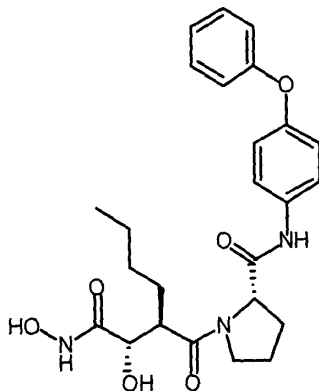
5



10

15

15

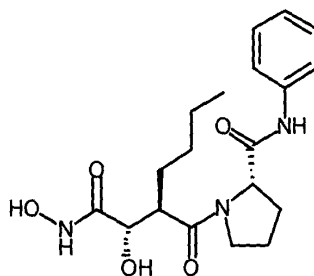


20

1.41-1.36 (m, 4H), 0.89 (t, J = 6.6 & 7.14 Hz, 3H). ES-MS: calcd. For C₂₅H₃₁N₃O₆ (469.54); found: 470.4 [M+1].

Example 110

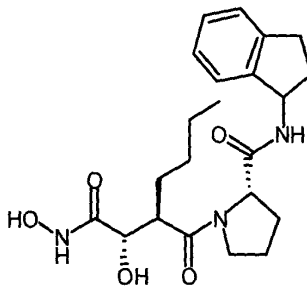
- 5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((phenyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



- 10 The title compound was prepared according to General Procedure F from aniline. ¹H NMR (CDCl₃): δ 7.52-7.03 (m, 6H), 4.58-4.55 (d, J = 8.0 Hz, 1H), 4.28-4.27 (d, J = 2.4 Hz, 1H), 3.71 (bs, 2H), 3.262 (bs, 1H), 2.31-1.77 (m, 6H), 1.41-1.33 (m, 4H), 0.89 (t, J = 6.6 & 7.4 Hz, 3H). ES-MS: calcd. For C₁₉H₂₇N₃O₅ (377.44); found: 378.3 [M+1].

Example 111

- 15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((indan-1-yl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



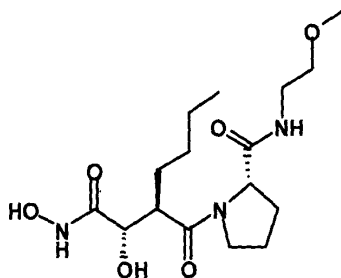
- 20 The title compound was prepared according to General Procedure F from 1-aminoindan. ¹H NMR (CDCl₃): δ 7.27-7.15 (m, 4H), 5.38 (t, J = 8.2 & 7.7 Hz, 1H),

4.45 (bs, 1H), 4.18 (bs, 1H), 3.64 (m, 2H), 3.20-3.18 (m, 1H), 2.98-2.49 (m, 4H), 2.24-1.73 (m, 6H), 1.95-1.326 (m, 4H), 0.88 (t, J = 6.0 & 5.5 Hz, 3H).
ES-MS: calcd. For C₂₂H₃₁N₃O₅ (417.51); found: 418.4 [M+1]

5

Example 112

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((2-methoxyethyl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



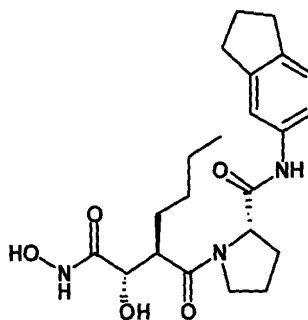
10

The title compound was prepared according to General Procedure F from 2-methoxyethylamine. ¹H NMR (CDCl₃): δ 4.45-4.27 (d, J = 6.87 Hz, 1H), 4.255 (bs, 1H), 3.69-3.29 (m, 9H), 2.15-1.77 (m, 6H), 1.43-1.3 (m, 4H), 0.92 (t, J = 6.593 & 6.867 Hz, 3H). ES-MS: calcd. For C₁₆H₂₉N₃O₆ (359.42); found: 360.3 [M+1].

15

Example 113

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((indan-5-yl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

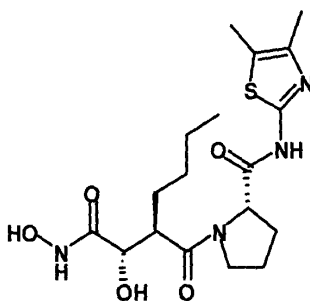


20

The title compound was prepared according to General Procedure F from 5-aminoindan. ¹H NMR (CDCl₃): δ 7.46-7.08 (m, 3H), 4.57-4.55 (d, J = 67.14 Hz, 1H), 4.28 (bs, 1H), 3.71 (bs, 2H), 3.26 (bs, 1H), 2.87-2.79 (dd, J = 6.87 & 7.14 Hz, 4H), 2.3-1.77 (m, 8H), 1.35 (bs, 4H), 0.89 (t, J = 6.32 & 6.87 Hz, 3H). ES-MS: calcd. For C₂₂H₃₁N₃O₅ (417.51); found: 418.4 [M+1].

Example 114

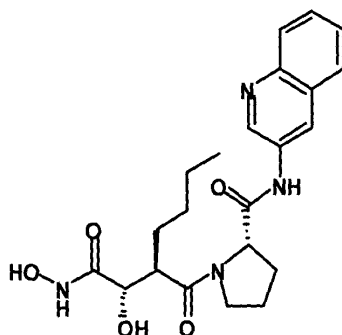
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4,5-dimethylthiazol-2-yl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from 2-amino-4,5-dimethylthiazole. ¹H NMR (CDCl₃): δ 4.60 (bs, 1H), 4.25 (bs, 1H), 3.79 (t, J = 5.77 & 4.67 Hz, 2H), 3.26 (bs, 1H), 2.30-2.24 (m, 8H), 1.74-2.12 (m, 4H), 1.36 (m, 4 H), 0.901 (t, J = 6.77 & 6.87 Hz, 3H). ES-MS: calcd. For C₁₈H₂₈N₄O₅S (412.51); found: 413.3 [M+1].

Example 115

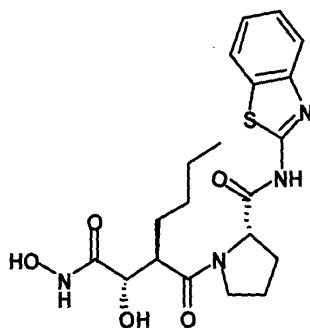
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((quinolin-3-yl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from 3-aminoquinoline. ¹H NMR (CDCl₃): δ 8.17-7.26 (m, 6H), 4.68 (m, 1H), 4.32 (m, 1H), 3.77-3.67 (d, J = 30.217 Hz, 2H), 3.22 (bs, 1H), 2.17-1.69 (m, 6H), 1.30 (bs, 4H), 0.89-0.82 (m, 3H). ES-MS: calcd. For C₂₂H₂₈N₄O₅ (428.49); found: 429.3 [M+1].

Example 116

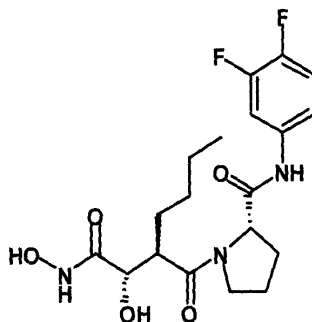
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((benzthiazol-2-yl)amino-carbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from 2-aminobenzothiazole. ¹H NMR (DMSO-d₆): δ 8.18-7.49 (m, 4H), 4.802 (bs, 1H), 3.98-3.94 (d, J = 9.066 Hz, 1H), 3.59 (bs, 2H), 3.11 (bs, 1H), 2.11-1.38 (m, 10H), 1.06-1.04 (m, 3H). ES-MS: calcd. For C₂₀H₂₆N₄O₅S (434.52); found: 435.3 [M+1].

Example 117

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((3,4-difluorophenyl)amino-carbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



5

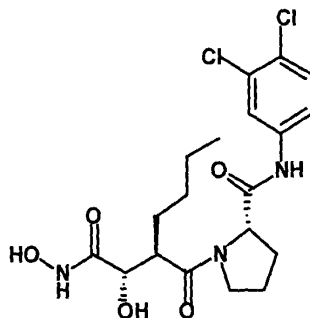
The title compound was prepared according to General Procedure F from 3,4-difluoroaniline. ¹H NMR (CDCl₃): δ 7.60-6.97 (m, 3H), 4.49-4.61 (d, J = 7.97 Hz, 1H), 4.29-4.28 (d, J = 2.2 Hz, 1H), 3.79-3.69 (m, 2H), 3.26 (bs, 1H), 2.36-1.76 (m, 6H), 1.49-1.35 (m, 4H), 0.918 (t, J = 6.867 & 7.143 Hz, 3H). ES-MS: calcd. For C₁₉H₂₅F₂N₃O₅ (413.42); found: 414.3 [M+1].

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Example 118

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((3,4-dichlorophenyl)amino-carbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

15



The title compound was prepared according to General Procedure F from 3,4-dichloroaniline. ¹H NMR (CDCl₃): δ 7.94-7.44 (m, 3H), 4.73-4.71 (d, J = 8.24 Hz,

20

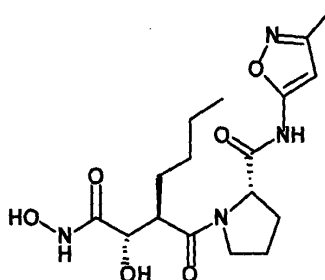
1H), 4.52-4.51 (d, J = 2.8 Hz, 1H), 3.95-3.94 (m, 2H), 3.49 (t, J = 5.8 & 6.0 Hz, 1H), 2.52-1.99 (m, 6H), 1.70-1.57 (m, 4H), 1.122 (t, J = 6.9 & 7.1 Hz, 3H).

ES-MS: calcd. For C₁₉H₂₅Cl₂N₃O₅ (445.1); found: 446.3 [M+1].

5

Example 119

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((5-methylisoxazol-3-yl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



10

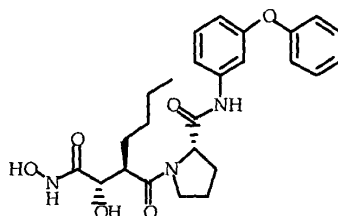
The title compound was prepared according to General Procedure F from 3-amino-5-methylisoxazole. ¹H NMR (DMSO-d₆): δ 6.64-5.95 (m, 1H), 4.66-4.62 (dd, J = 4.9 & 4.7 Hz, 1H), 4.01-3.93 (m, 1H), 3.76-3.70 (m, 1H), 3.56 (bs, 3H), 3.11-3.05 (t, J = 8.8, 1H), 2.70-2.00 (m, 6H), 1.59-1.37 (m, 4H), 1.02 (t, J = 5.8 & 7.1 Hz, 3H). ES-MS: calcd. For C₁₇H₂₆N₄O₆ (382.42); found: 383.3 [M+1].

15

Example 120

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((3-phenoxyphenyl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

20



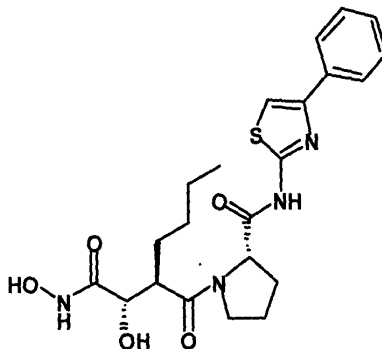
The title compound was prepared according to General Procedure F from 3-phenoxyaniline. ¹H NMR (CDCl₃): δ 7.55-6.88 (m, 9H), 4.75-4.72 (d, J = 7.7 Hz,

1H), 4.47 (bs, 1H), 3.90-3.88 (m, 2H), 3.46-3.44 (m, 1H), 2.51-1.96 (m, 6H), 1.65-1.53 (m, 4H), 1.09 (t, J = 6.7 & 7.1 Hz, 3H). ES-MS: calcd. For C₂₅H₃₁N₃O₆ (469.54); found: 470.4 [M+1].

5

Example 121

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4-phenylthiazol-2-yl)amino-carbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



10

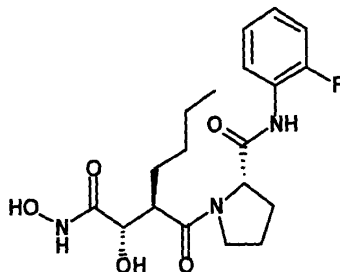
The title compound was prepared according to General Procedure F from 2-amino-5-phenylthiazole. ¹H NMR (CDCl₃): δ 7.94-7.28 (m, 6H), 4.89-4.88 (d, J = 4.4 Hz, 1H), 4.47-4.47 (d, J = 2.5 Hz, 1H), 3.92-4.05 (m, 2H), 3.48-3.44 (m, 1H), 2.54-1.95 (m, 6H), 1.57-1.48 (m, 4H), 1.10 (t, J = 6.6 & 7.7 Hz, 3H). ES-MS: calcd. For C₂₂H₂₈N₄O₅S (460.55); found: 461.2 [M+1].

15

Example 122

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((2-fluorophenyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

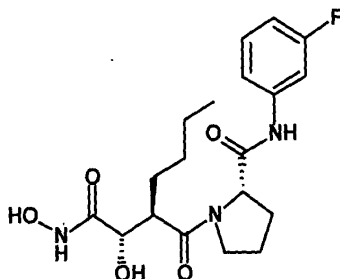
20



The title compound was prepared according to General Procedure F from 2-fluoroaniline. ¹H NMR (CDCl₃): δ 8.42-7.23 (m, 4H), 4.97-4.95 (d, J = 6.9 Hz, 1H), 4.49 (bs, 1H), 3.96-3.83 (m, 2H), 3.49 (t, J = 5.5 & 7.4 Hz, 1H), 2.61-2.01 (m, 6H), 1.64-1.46 (m, 4H), 1.06 (t, J = 6.6 & 7.1 Hz, 3H). ES-MS: calcd. For C₁₉H₂₆FN₃O₅ (395.43); found: 396.4 [M+1].

Example 123

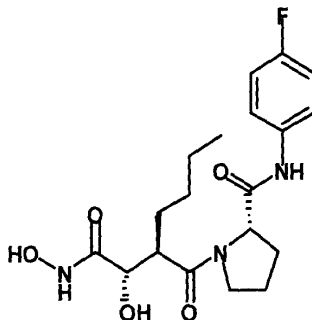
Synthesis of *N*-hydroxy-3-((*R*)-((*n*-butyl)-3-[(2-(*S*)-((3-fluorophenyl)aminocarbonyl)pyrrolidin-1-carbonyl)]-2-(*S*)-hydroxypropionamide)



The title compound was prepared according to General Procedure F from 3-fluoroaniline. ¹H NMR (CDCl₃): δ 7.66-6.92 (m, 4H), 4.75-4.73 (d, J = 8.0 Hz, 1H), 4.52 (bs, 1H), 3.94 (t, J = 8.5 & 8.81 Hz, 2H), 3.49 (bs, 1H), 2.57-1.99 (m, 6H), 1.70-1.56 (m, 4H), 1.12 (t, J = 6.6 & 6.9 Hz, 3H). ES-MS: calcd. For C₁₉H₂₆FN₃O₅ (395.43); found: 396.3 [M+1].

Example 124

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4-fluorophenyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



5

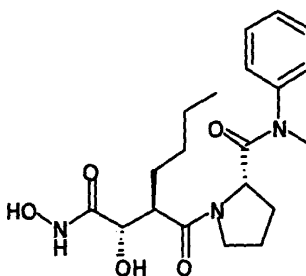
The title compound was prepared according to General Procedure F from 4-fluoroaniline. ¹H NMR (CDCl₃): δ 7.71-7.13 (m, 4H), 4.74-4.71 (d, J = 8.2 Hz, 1H), 4.51-4.49 (d, J = 2.8 Hz, 1H), 3.96-3.90 (m, 2H), 3.52-3.46 (m, 1H), 2.58-1.96 (m, 6H), 1.69-1.54 (m, 4H), 1.11 (t, J = 6.9 Hz, 3H). ES-MS: calcd. For C₁₉H₂₆FN₃O₅ (395.43); found: 396.3 [M+1].

10

Example 125

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((*N*-phenyl-*N*-methylamino)-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

15



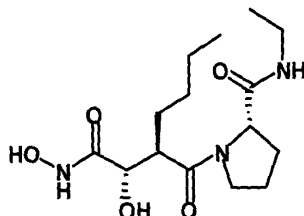
The title compound was prepared according to General Procedure F from *N*-methylaniline. ¹H NMR (CDCl₃): δ 7.26-7.5 (m, 5H), 4.38 (d, J = 7.1 Hz, 1H), 4.24 (bs, 1H), 3.69-3.65 (m, 5H), 3.33-3.20 (m, 1H), 2.08-1.82 (m, 6H), 1.49-1.36 (m, 4H),

20

0.94 (t, J = 7.1 Hz, 3H). ES-MS: calcd. For C₂₀H₂₉N₃O₅ (391.47); found: 392.4 [M+1].

Example 126

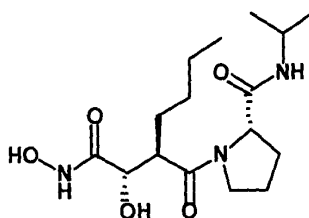
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((ethyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from ethylamine. ¹H NMR (CDCl₃): δ 4.39-4.37 (d, J = 6.0 Hz, 1H), 4.25-4.24 (d, J = 2.5 Hz, 1H), 3.69-3.52 (m, 4H), 3.20-3.32 (m, 1H), 2.25-1.76 (m, 6H), 1.44-1.25 (m, 4H), 1.183-1.11 (m, 3H), 0.94-0.85 (m, 3H). ES-MS: calcd. For C₁₅H₂₇N₃O₅ (329.4); found: 330.4 [M+1].

Example 127

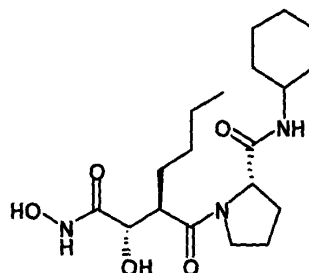
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((2-propyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from 2-aminopropane. ¹H NMR (CDCl₃): δ 4.41-4.38 (d, J = 8.0 Hz, 1H), 4.26-4.25 (d, J = 2.2 Hz, 1H), 4.01-3.94 (dd, J = 6.6 Hz, 1H), 3.66 (t, J = 7.4 Hz, 2H), 3.25-3.22 (m, 1H), 2.21-1.77 (m, 6H), 1.44-1.22 (m, 4H), 1.19-1.11 (m, 6H), 0.893 (t, J = 6.6 Hz, 3H). ES-MS: calcd. For C₁₆H₂₉N₃O₅ (343.42); found: 344.4 [M+1].

Example 130

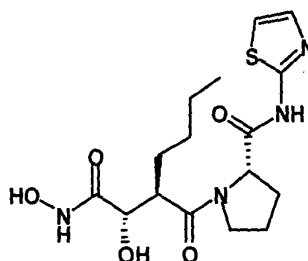
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((cyclohexyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from cyclohexylamine. ^1H NMR (CDCl_3): δ 4.43-4.40 (d, J = 8.0 Hz, 1H), 4.26-4.25 (d, J = 2.5 Hz, 1H), 3.66-3.63 (d, J = 7.4 Hz, 3H), 3.27-3.21 (m, 1H), 2.21-1.10 (m, 20H), 0.94-0.89 (m, 3H). ES-MS: calcd. For $\text{C}_{19}\text{H}_{33}\text{N}_3\text{O}_5$ (383.49); found: 384.3 [$\text{M}+1$].

Example 131

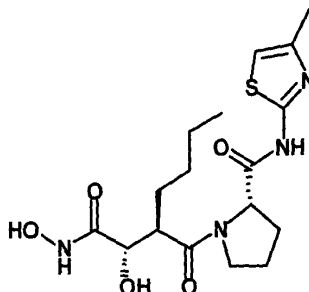
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((thiazol-2-yl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from 2-aminothiazole. ^1H NMR (CDCl_3): δ 7.5-7.04 (m, 2H), 4.66 (t, J = 5.0 Hz, 1H), 4.27-4.26 (d, J = 2.5 Hz, 1H), 3.86-3.76 (m, 2H), 3.3-3.25 (m, 1H), 2.34-1.74 (m, 6H), 1.36-1.28 (m, 4H), 0.93-0.86 (m, 3H). ES-MS: calcd. For $\text{C}_{16}\text{H}_{24}\text{N}_4\text{O}_5\text{S}$ (384.46); found: 385.2 [$\text{M}+1$].

Example 132

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4-methylthiazol-2-yl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



5

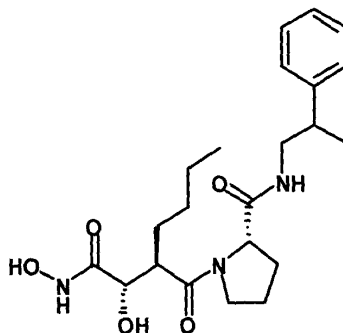
The title compound was prepared according to General Procedure F from 2-amino-4-methylthiazole. ¹H NMR (CDCl₃): δ 6.62-6.61(d, J = 1.1 Hz, 1H), 4.65-4.63 (dd, J = 4.7 & 5.2 Hz, 1H), 4.26-4.25 (d, J = 2.5 Hz, 1H), 3.85-3.78 (dd, J = 6.0 & 7.4 Hz, 2H), 3.29-3.25 (dd, J = 5.2 & 5.0 Hz, 1H), 2.46-1.69 (m, 9H), 1.38-1.27 (m, 4H), 0.893-0.85 (m, 3H). ES-MS: calcd. For C₁₇H₂₆N₄O₅S (398.48); found: 399.3 [M+1].

10

Example 133

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((2-phenylpropyl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

15



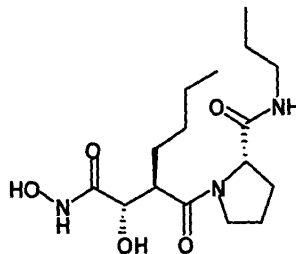
The title compound was prepared according to General Procedure F from 1-amino-2-phenylpropane. ¹H NMR (CDCl₃): δ 7.3-6.78 (m, 5H), 5.17 (bs, 1H), 4.34 (bs, 1H), 4.21 (bs, 1H), 3.61-3.16 (m, 4H), 3.25-3.22 (m, 1H), 2.92 (bs, 1H), 2.09-

20

1.09 (m, 13H), 0.94-0.83 (m, 3H). ES-MS: calcd. For C₂₂H₃₃N₃O₅ (419.52); found: 420.3 [M+1].

Example 134

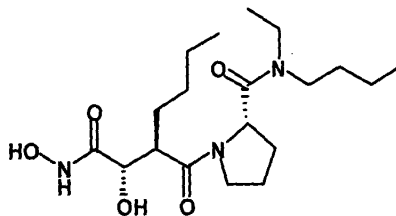
5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((n-propyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



10 The title compound was prepared according to General Procedure F from propylamine. ¹H NMR (CDCl₃): δ 4.44-4.41 (d, J = 7.4 Hz, 1H), 4.25 (bs, 1H), 3.67-3.65 (d, J = 5.5 Hz, 2H), 3.24-3.14 (m, 3H), 2.23-1.79 (m, 6H), 1.54-1.35 (m, 6H), 0.94-0.85 (m, 6H). ES-MS: calcd. For C₁₆H₂₉N₃O₅ (343.42); found: 344.4 [M+1].

Example 135

15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((*N*-butyl-*N*-methylamino)carbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



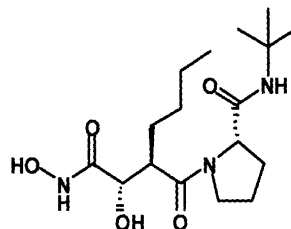
20

The title compound was prepared according to General Procedure F from *N*-ethyl-*n*-butylamine. ¹H NMR (CDCl₃): δ 4.74 (t, J = 3.9 Hz, 1H), 4.25 (bs, 1H), 3.73-3.02 (m, 7H), 2.16-1.74 (m, 6H), 1.53-1.23 (m, 8H), 1.08 (t, J = 6.9 & 7.1 Hz,

2H), 0.98-0.88 (m, 9H). ES-MS: calcd. For $C_{19}H_{35}N_3O_5$ (358.50); found: 386.4 [M+1].

Example 136

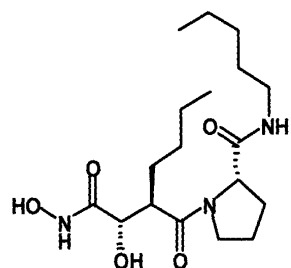
- 5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((*tert*-butyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



- 10 The title compound was prepared according to General Procedure F from *t*-butylamine. 1H NMR ($CDCl_3$): δ 4.36-4.34 (d, J = 6.7 Hz, 1H), 4.31-4.25 (d, J = 6.5 Hz, 1H), 3.65-3.55 (m, 2H), 3.26-3.22 (m, 1H), 2.2-1.8 (m, 6H), 1.5-1.3 (m, 13H), 0.94-0.85 (m, 3H). ES-MS: calcd. For $C_{17}H_{31}N_3O_5$ (357.45); found: 358.4 [M+1].

Example 137

- 15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((*n*-pentyl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

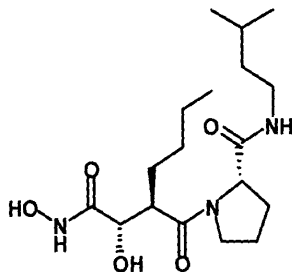


- 20 The title compound was prepared according to General Procedure F from *n*-pentylamine. 1H NMR ($CDCl_3$): δ 4.44-4.41 (d, J = 7.4 Hz, 1H), 4.24 (d, J = 2.2 Hz, 1H), 3.71-3.62 (m, 2H), 3.27-3.15 (m, 3H), 2.26-1.74 (m, 6H), 1.52-1.24 (m, 10H), 0.94-0.86 (m, 6H). ES-MS: calcd. For $C_{18}H_{33}N_3O_5$ (371.48); found: 372.4 [M+1].

5

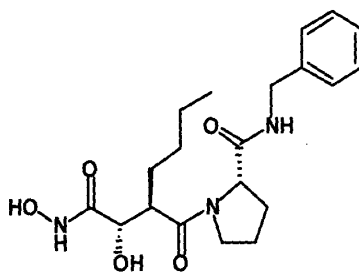
Example 138

Synthesis of *N*-hydroxy-3-(*R*)-(3-(2-(*S*)-((3-methylbutyl)aminocarbonyl)pyrrolidin-1-carbonyl)-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from 3-methyl-1-butylamine. ¹H NMR (CDCl₃): δ 4.44-4.41 (d, J = 7.4 Hz, 1H), 4.25-4.24 (d, J = 2.5 Hz, 1H), 3.71-3.61 (m, 2H), 3.27-3.17 (m, 3H), 2.64-1.77 (m, 6H), 1.63-1.33 (m, 7H), 0.94-0.88 (m, 9H). ES-MS: calcd. For C₁₈H₃₃N₃O₅ (271.48); found: 372.5 [M+1].

15 **Example 139**
Synthesis of *N*-hydroxy-3-(*R*)-(3-(2-(*S*)-((benzyl)aminocarbonyl)pyrrolidin-1-carbonyl)-2-(*S*)-hydroxypropionamide

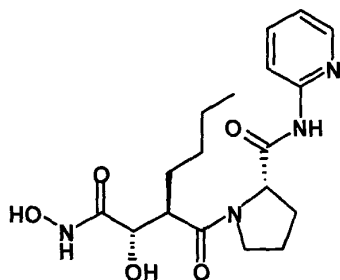


20 The title compound was prepared according to General Procedure F from benzylamine. ¹H NMR (CDCl₃): δ 7.37-7.21 (m, 5H), 4.49-4.29 (m, 3H), 4.20-4.19 (d, J = 2.5 Hz 1H), 3.71-3.62 (m, 2H), 3.19 (t, J = 7.4 & 5.5 Hz, 1H), 2.22-1.73 (m,

6H), 1.32-1.29 (m, 4H), 0.88 (t, J = 6.6 & 6.9 Hz, 3H). ES-MS: calcd. For $C_{20}H_{29}N_3O_5$ (391.47); found: 392.4 [M+1].

Example 140

- 5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((pyridin-2-yl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

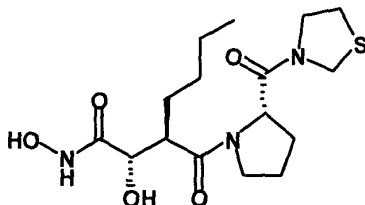


- 10 The title compound was prepared according to General Procedure F from 2-aminopyridine. 1H NMR ($CDCl_3$): δ 8.4-7.47 (m, 4H), 4.87-4.83 (m, 1H), 4.47-4.46 (d, J = 2.8 Hz, 1H), 4.04-3.87 (m, 2H), 3.5-3.48 (t, J = 2.8 & 4.9 Hz, 1H), 2.52-1.95 (m, 6H), 1.63-1.56 (m, 4H), 1.11 (t, J = 7.1 Hz, 3H). ES-MS: calcd. For $C_{18}H_{26}N_4O_5$ (378.43); found: 377.2 [M-1].

15

Example 141

- 15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((thiazolidin-1-yl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



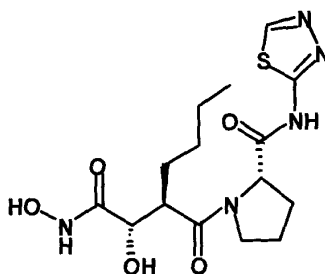
20

The title compound was prepared according to General Procedure F from thiazolidine. 1H NMR ($CDCl_3$): δ 4.94-4.66 (m, 3H), 4.46-4.45(d, J = 2.2 Hz, 1H), 4.24-3.84 (m, 4H), 3.46-3.18 (m, 3H), 2.37-2.01 (m, 6H), 1.68-1.53 (m, 4H), 1.12 (t, J

= 7.417 & 6.767 Hz, 3H). ES-MS: calcd. For $C_{16}H_{27}N_3O_5S$ (373.47); found: 374.6 [M+1].

Example 142

- 5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((thiadiazolidin-5-yl)aminocarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

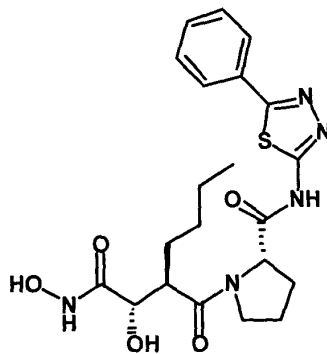


- 10 The title compound was prepared according to General Procedure F from 2-aminothiadiazole. 1H NMR ($CDCl_3$): δ 7.47-7.46 (d, J = 5.5 Hz, 1H), 5.03-5.02 (d, J = 5.5 Hz, 1H), 4.49-4.47 (d, J = 3.4 Hz, 1H), 4-3.89 (m, 2H), 3.45-3.44 (d, J = 3.6 Hz, 1H), 2.4-1.9 (m, 6H), 1.53 (bs, 4H), 1.08 (t, J = 6.6 & 6.9 Hz, 3H). ES-MS: calcd. For $C_{15}H_{23}N_5O_5S$ (385.44); found: 386.5 [M+1].

15

Example 143

- Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((5-phenylthiadiazolidin-2-yl)aminocarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

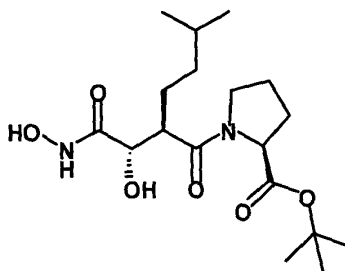


20

The title compound was prepared according to General Procedure F from 2-amino-5-phenylthiadiazole. ¹H NMR (CDCl₃): δ 7.82-7.21 (m, 5H), 4.82-4.79 (d, J = 7.4 Hz, 1H), 4.24-4.23 (d, J = 3.6 Hz, 1H), 3.76-3.62 (m, 2H), 3.20-3.19 (d, J = 3.6 Hz, 1H), 2.18-1.95 (m, 6H), 1.68-1.66 (m, 4H), 0.807 (t, J = 6.6 & 7.2 Hz, 3H). ES-MS: calcd. For C₂₁H₂₇N₅O₅S (461.54); found: 462.7 [M+1].

Example 144

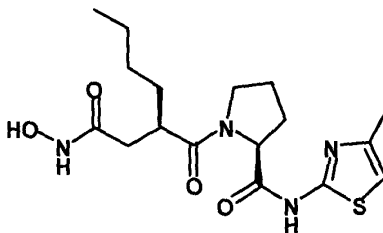
Synthesis of *N*-hydroxy-3-(*R*)-(3-methylbutyl)-3-[2-(*S*)-(tert-butoxycarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



The title compound was prepared according to General Procedure F from 3-methyl-1-bromo-2-butene and proline -O-t-butyl ester. ¹H NMR (CDCl₃): δ 4.52 (t, J = 4.4 Hz, 1H), 4.46 (t, J = 1.3 & 2.2 Hz, 1H), 3.93-3.76 (m, 1H), 3.4-3.34 (m, 2H), 2.41-1.95 (m, 6H), 1.81-1.49 (m, 12H), 1.10 (t, J = 6.6 & 6.9 Hz, 6H). ES-MS: calcd. For C₁₈H₃₂N₂O₆ (372.46); found: 373.5 [M+1].

Example 145

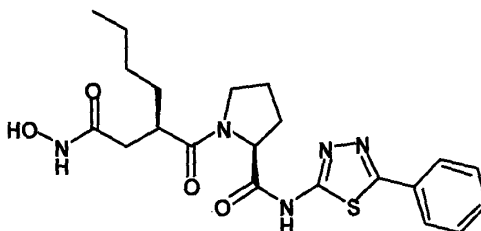
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4-methylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]propionamide



The title compound was prepared according to General Procedure E from 2-amino-4-methylthiazole. ¹H NMR (DMSO-d₆): δ 6.74 (s, 1H), 4.48 (dd, 8.5 & 4.7 Hz, 1H), 3.75-3.63 (m, 1H), 3.61-3.55 (m, 1H), 2.95 (bs, 1H), 2.25 (s, 3H), 2.23-1.80 (m, 6H), 1.45-1.25 (m, 6H), 0.85 (t, 6.6 Hz, 3H). ES-MS: cald. For C₁₇H₂₆N₄O₄S (382.17); found 383.6 [M+1].

Example 146

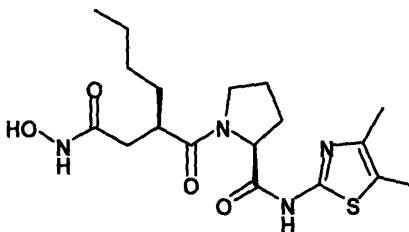
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((5-phenylthiadiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]propionamide



The title compound was prepared according to General Procedure E from 2-amino-5-phenylthiadiazole. ¹H NMR (DMSO-d₆): δ 10.3 (s, 1H), 7.94 (m, 2H), 7.53 (m, 3H), 4.56 (dd, 8.5 & 4.8 Hz, 1H), 3.8-3.59 (m, 2H), 2.96 (bs, 1H), 2.29-1.86 (m, 6H), 1.45-1.27 (m, 6H), 0.87 (t, 6.6 Hz, 3H). ES-MS: cald. For C₂₁H₂₇N₅O₄S (445.18); found 446.5 [M+1].

Example 147

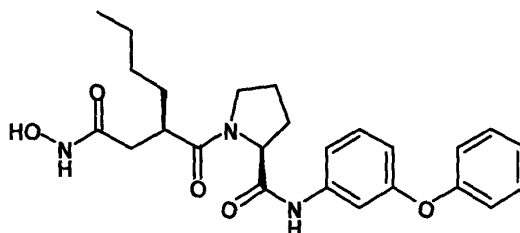
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4,5-dimethylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]propionamide



The title compound was prepared according to General Procedure E from 2-amino-4,5-dimethylthiazole. ¹H NMR (DMSO-d₆): δ 4.45 (dd, 8.2 & 4.8 Hz, 1H), 3.74-3.62 (m, 1H), 3.60-3.55 (m, 1H), 2.93 (bs, 1H), 2.22 (s, 3H), 2.15 (s, 3H), 2.11-1.78 (m, 6H), 1.46-1.25 (m, 6H), 0.85 (t, 6.3 Hz, 3 H). ES-MS: calcd. For C₁₈H₂₈N₄O₄S (396.18); found 397.5 [M+1].

Example 148

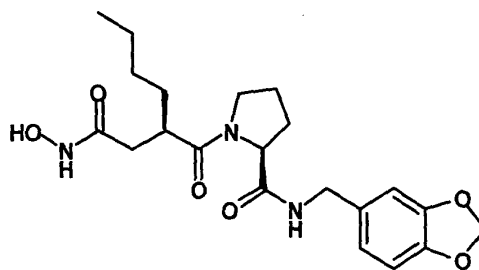
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((3-phenoxyphenyl)amino-carbonyl)pyrrolidin-1-carbonyl]propionamide



The title compound was prepared according to General Procedure E from 3-phenoxyaniline. ¹H NMR (DMSO-d₆): δ 7.42 (m, 2H), 7.37 (m, 3H), 7.15 (m, 1H), 7.02 (m, 2H), 6.69 (m, 1H), 4.35 (dd, 8.0 & 4.5 Hz, 1H), 3.71-3.45 (m, 2H), 2.93 (bs, 1H), 2.28-1.82 (m, 6H), 1.42-1.22 (m, 6H), 0.82 (t, 6.3 Hz, 3H). ES-MS: calcd. For C₂₅H₃₁N₃O₅ (453.23); found 454.5 [M+1].

Example 149

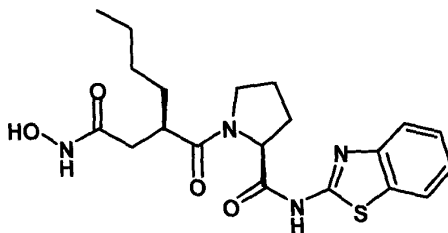
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((3,4-methylenedioxybenzyl)amino-carbonyl)pyrrolidin-1-carbonyl]propionamide



The title compound was prepared according to General Procedure E from piperonylamine. ¹H NMR (DMSO-d₆): δ 10.4 (bs, 1H), 8.18 (m, 1H), 6.87-6.69 (m, 3H), 6.00-5.96 (m, 2H), 4.29-4.11 (m, 2H), 3.71-3.53 (m, 2H), 2.92 (bs, 1H), 2.29-1.76 (m, 6H), 1.49-1.21 (m, 6H), 0.84 (m, 3H). ES-MS: calcd. For C₂₁H₂₉N₃O₆ (419.21); found 420.5 [M+1].

Example 150

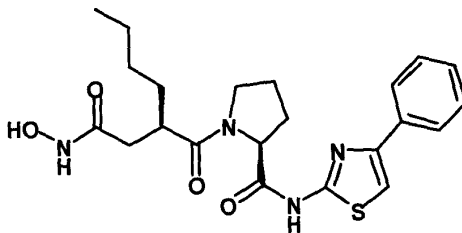
Synthesis of *N*-hydroxy-3-(*S*)-(n-butyl)-3-[2-(*S*)-((benzthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]propionamide



The title compound was prepared according to General Procedure E from 2-aminobenzothiazole. ES-MS: calcd. For C₂₀H₂₆N₄O₄S (418.17); found 419.4 [M+1].

Example 151

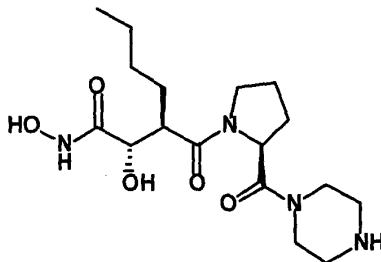
Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4-phenylthiazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]propionamide



The title compound was prepared according to General Procedure E from 2-amino-4-phenylthiazole. ES-MS: calcd. For C₂₂H₂₈N₄O₄S (444.18); found 445.5 [M+1].

Example 152

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(piperazin-1-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



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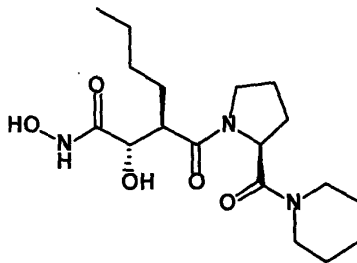
The title compound was prepared according to General Procedure F from piperazine. ¹H NMR (CD₃OD): δ 4.25-4.15 (m, 2H), 4.14-3.82 (m, 4H), 3.72-3.45 (m, 6H), 3.36-3.29 (m, 1H), 2.46-2.04 (m, 4H), 1.83-1.49 (m, 6H), 1.12 (t, J = 7 Hz).

10 ES-MS: calcd. For C₁₇H₃₀N₄O₅ (370.44); found: 371.4 [M+1].

Example 153

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(piperidin-1-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

15

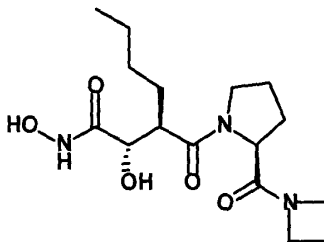


The title compound was prepared according to General Procedure F from piperidine. ¹H NMR (CDCl₃): δ 5.07-5.03 (m, 1H), 4.45 (d, J = 2.6 Hz, 1H), 3.97-3.82 (m, 4H), 3.71-3.56 (m, 2H), 3.47-3.40 (m, 1H), 2.37-2.14 (m, 4H), 2.09-1.98 (m, 4H), 1.96-1.61 (m, 4H), 1.59-1.52 (m, 4H), 1.12 (t, J = 7 Hz, 3H). ES-MS: calcd. For C₁₈H₃₁N₃O₅ (369.46); found: 370.3 [M+1].

20

Example 154

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(azetidin-1-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



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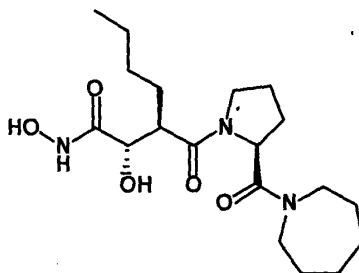
The title compound was prepared according to General Procedure F from azetidine. ¹H NMR (CDCl₃): δ 4.67-4.55 (m, 2H), 4.53-4.31 (m, 3H), 4.28-4.16 (m, 1H), 3.94-3.83 (m, 1H), 3.81-3.77 (m, 1H), 3.43-3.38 (m, 1H), 2.55-2.45 (m, 2H), 2.37-2.22 (m, 2H), 2.20-2.07 (m, 2H), 2.05-1.91 (m, 2H), 1.66-1.47 (m, 4H), 1.01 (t, J = 7 Hz, 3H). ES-MS: calcd. For C₁₆H₂₇N₃O₅ (341.40); found: 342.3 [M+1].

10

Example 155

Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(homopiperazin-1-ylcarbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

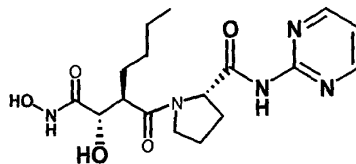
15



The title compound was prepared according to General Procedure F from hexamethyleneimine. ¹H NMR (CDCl₃): δ 5.00-4.96 (m, 1H), 4.44 (d, J = 2.7 Hz, 1H), 3.97-3.82 (m, 2H), 3.79-3.59 (m, 4H), 3.44-3.38 (m, 1H), 2.41-2.30 (m, 2H), 2.19-1.83 (m, 8H), 1.82-1.69 (m, 4H), 1.67-1.50 (m, 4H), 1.10 (t, J = 7 Hz, 3H). ES-MS: calcd. For C₁₉H₃₃N₃O₅ (383.48); found: 384.4 [M+1].

20

Example 156
 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(pyrimidin-2-yl)amino-carbonyl]pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



Step 1

To Cbz-protected-L-proline (20 mmol) in DCM (100 mL) was added thionylchloride (200 mmol) and the solution heated to reflux for 20 min. The reaction was concentrated to dryness and the residue coevaporated two times with DCM. An aliquot (6.7 mmol) in DCM (3 mL) was added to a 0 °C solution of 2-amino-
 10 pyrimidine in pyridine (3 mL) and the reaction stirred overnight. The reaction was concentrated, the residue dissolved in ethylacetate and then washed with water, 10 % citric acid, saturated NaHCO₃ and brine, then dried (Na₂SO₄) to afford N-Cbz-(2-(*S*)-pyrimidin-2-ylaminocarbonyl)pyrrolidine, which was used without further purification.

Step 2

To afford N-Cbz-(2-(*S*)-pyrimidin-2-ylaminocarbonyl)pyrrolidine (5.0 mmol) in HOAc (10 mL) was added 30 % HBr in acetic acid and the solution stirred for 40 min. The reaction was quenched by addition of 100 mL ethylether, and the resulting precipitate collected and recrystallized from MeOH/Et₂O to afford 3.5 mmol afford of
 20 2-(*S*)-(pyrimidin-2-ylaminocarbonyl)pyrrolidine hydrobromide salt (70 %).

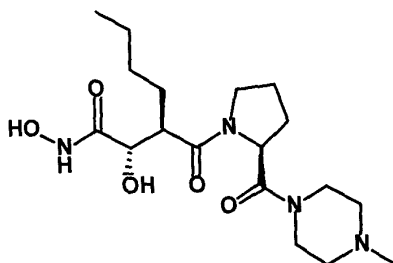
Step 3

To 2-(*S*)-(pyrimidin-2-ylaminocarbonyl)pyrrolidine hydrobromide (200 μmol) in DMF (2 mL) was added DIEA (500 μmol), compound **G-1**, (General Procedure G, 200 μmol) and solid HATU (200 μmol) and the reaction stirred 4 h. The reaction was
 25 cooled to 0 °C, diluted with aqueous 50 % hydroxylamine (600 μL), stirred for 4 h, and then purified via preparative reverse-phase (C18) HPLC to afford the title compound. ¹H NMR (DMSO-d₆): δ 10.85 (bs, 1H), 8.84 (d, J = 5.0 Hz, 2H), 7.37 (t, J = 5.0 Hz, 1H), 4.98-4.83 (bs, 1H), 4.04-3.95 (m, 2H), 3.78-3.65 (m, 1H), 3.18-3.05

(m, 1H), 2.39-2.25 (m, 4H), 1.57-1.38 (m, 6H), 1.00 (t, J = 6.6 Hz, 3H). ES-MS: calcd. For C₁₇H₂₅N₅O₅ (379.4162); found: 380.3 [M+1].

Example 157

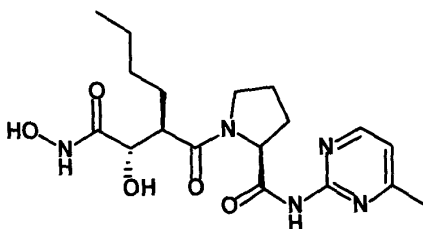
- 5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(4-methylpiperazin-1-ylcarbonyl)-pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



- 10 The title compound was prepared according to General Procedure F from *N*-methylpiperazine. ¹H NMR (CD₃OD): δ 4.24-4.12 (m, 2H), 3.89-3.86 (m, 2H), 3.64-3.51 (m, 4H), 3.35-3.19 (m, 1H), 3.14 (s, 3H), 2.46-2.08 (m, 4H), 1.85-1.53 (m, 6H), 1.11 (t, J = 7 Hz). ES-MS: calcd. For C₁₈H₃₂N₄O₅ (384.47); found: 385.3 [M+1].

Example 158

- 15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((4-methylpyrimidin-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide

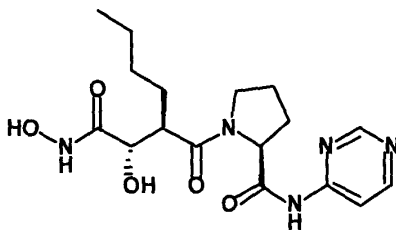


- 20 The title compound was prepared as described in General Procedure F from 4-methyl-2-aminopyrimidine. ¹H NMR (DMSO-d₆): δ 8.57 (d, J = 5.2 Hz, 1H), 7.16 (d, J = 5.2 Hz, 1H), 4.9 (bs, 1H), 3.93-3.85 (m, 2H), 3.67-3.60 (m, 1H), 3.02-2.90 (m,

1H), 2.50 (s, 3H), 2.3-2.15 (m, 1H), 2.10-1.98 (m, 3H), 1.55-1.28 (m, 6H), 0.904 (t, J = 6.2 Hz, 3H). ES-MS: calcd. For C₁₈H₂₇N₅O₅ (393.4431); found: 394.3 [M+1].

Example 159

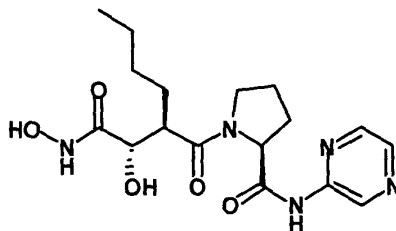
5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((pyrimidin-4-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



10 The title compound was prepared as described in General Procedure F from 4-aminopyrimidine. ¹H NMR (DMSO-d₆): δ 8.91 (d, J = 0.55 Hz, 1H), 8.66 (d, J = 6.1 Hz, 1H), 8.04 (dd, J = 6.1 & 1.1 Hz, 1H), 4.64-4.60 (m, 1H), 3.87-3.75 (m, 1H), 3.61-3.51 (m, 1H), 2.93-2.88 (m, 1H), 2.17-2.05 (m, 1H), 1.98-1.83 (m, 3H), 1.45-1.18 (m, 6H), 0.83 (t, J = 6.3 Hz, 3H). ES-MS: calcd. For C₁₇H₂₅N₅O₅ (379.4162); found: 380.1 [M+1].

Example 160

15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((pyrazin-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



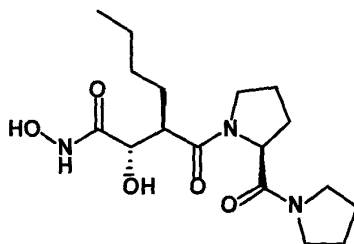
20

The title compound was prepared as described in General Procedure F from aminopyrazine. ¹H NMR (DMSO-d₆): δ 9.30 (d, J = 1.4 Hz, 1H), 8.41-8.35 (m, 2H), 4.66-4.62 (m, 1H), 3.88-3.76 (m, 2H), 3.60-3.53 (m, 1H), 2.94-2.89 (m, 1H), 2.17-

2.11 (m, 1H), 2.00-1.84 (m, 3H), 1.42-1.18 (m, 6H), 0.82 (t, J = 6.6 Hz, 3H). ES-MS: calcd. For C₁₇H₂₅N₅O₅ (379.4162); found: 380.4 [M+1].

Example 161

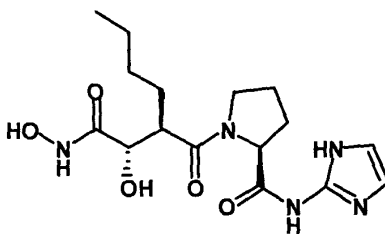
- 5 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-(pyrrolidin-1-ylcarbonyl)pyrrolidin-1-ylcarbonyl]-2-(*S*)-hydroxypropionamide



- 10 The title compound was prepared according to General Procedure F from pyrrolidine. ¹H NMR (CDCl₃): δ 4.83-4.79 (m, 1H), 4.44 (d, J = 2.4 Hz, 1H), 3.96-3.85 (m, 2H), 3.77-3.73 (m, 2H), 3.64-3.56 (m, 2H), 3.42-3.16 (m, 1H), 2.39-2.22 (m, 2H), 2.19-1.96 (m, 8H), 1.66-1.50 (m, 4H), 1.11 (t, J = 7 Hz, 3H). ES-MS: calcd. For C₁₇H₂₉N₃O₅ (355.43); found: 356.4 [M+1].

Example 162

- 15 Synthesis of *N*-hydroxy-3-(*R*)-(n-butyl)-3-[2-(*S*)-((imidazol-2-yl)amino-carbonyl)pyrrolidin-1-carbonyl]-2-(*S*)-hydroxypropionamide



- 20 The title compound was prepared as described in General Procedure F from 2-amino-imidazole. ¹H NMR (DMSO-d₆): δ 7.24 (s, 2H), 4.50-4.46 (m, 1H), 3.83-3.61 (m, 3H), 2.94-2.88 (m, 1H), 2.21-2.11 (m, 1H), 2.05-1.94 (m, 3H), 1.41-1.18 (m, 6H),

0.81 (t, J = 6.0 Hz, 3H). ES-MS: calcd. For C₁₆H₂₅N₅O₅ (367.4052); found: 368.4 [M+1].

Formulation Examples

The following are representative pharmaceutical formulations containing a
5 compound of Formula (I).

Example 1

Tablet formulation

The following ingredients are mixed intimately and pressed into single scored
tablets.

10

Quantity per	
Ingredient	tablet, mg
compound of this invention	400
cornstarch	50
15 croscarmellose sodium	25
lactose	120
magnesium stearate	5

Example 2

20

Capsule formulation

The following ingredients are mixed intimately and loaded into a hard-shell
gelatin capsule.

25

Quantity per	Ingredient capsule,
mg	
compound of this invention	200
lactose, spray-dried	148
magnesium stearate	2

30

Example 3

Suspension formulation

The following ingredients are mixed to form a suspension for oral administration.

	Ingredient	Amount
5	compound of this invention	1.0 g
	fumaric acid	0.5 g
	sodium chloride	2.0 g
	methyl paraben	0.15 g
	propyl paraben	0.05 g
10	granulated sugar	25.0 g
	sorbitol (70% solution)	13.00 g
	Veegum K (Vanderbilt Co.)	1.0 g
	flavoring	0.035 ml
	colorings	0.5 mg
15	distilled water	q.s. to 100 ml

Example 4

Injectable formulation

The following ingredients are mixed to form an injectable formulation.

20	Ingredient	
	Amount	
	compound of this invention	0.2 mg-20 mg
	sodium acetate buffer solution, 0.4 M	2.0 ml
25	HCl (1N) or NaOH (1N)	q.s. to suitable pH
	water (distilled, sterile)	q.s. to 20 ml

30

Example 5

Suppository formulation

A suppository of total weight 2.5 g is prepared by mixing the compound of the invention with Witepsol® H-15 (triglycerides of saturated vegetable fatty acid;

5 Riches-Nelson, Inc., New York), and has the following composition:

compound of the invention	500 mg
Witepsol® H-15	
balance	

10

Biological Examples

Example 1

Inhibition of peptide deformylase activity

The PDF/FDH coupled assay (Lazennec, C. & Meinnel, T., Anal. Biochem. 224:180-182 (1997)) was used. In this coupled assay, the formate released by PDF from its substrate fMAS is oxidized by the coupling enzyme FDH, reducing one molecule of NAD⁺ to NADH, which causes an increase in absorption at 340 nm. All assays were carried out at room temperature in a buffer of 50 mM HEPES, pH 7.2, 10 mM NaCl, 0.2 mg/mL BSA, in half-area 96-well microtiter plates (Corning). The reaction was initiated by adding a mixture of 0.5 Unit/mL FDH, 1 mM NAD⁺, and fMAS at the desired concentration. To determine IC₅₀ (the concentration needed to inhibit 50% of enzyme activity) values, PDF was pre-incubated for 10 min with varying concentrations of actinonin, and the deformylation reaction was initiated by the addition of reaction mixture containing 4 mM fMAS. The initial reaction velocity, y, was measured as the initial rate of absorption increase at 340 nm using a SpectraMax plate reader (Molecular Devices, Sunnyvale, CA). The inhibitor concentration [In] at which 50% of the enzyme activity is inhibited, IC₅₀, was calculated using the following formula:

$$y = y_0 / (1 + [\text{In}] / \text{IC}_{50})$$

where y₀ is the reaction velocity in the absence of inhibitor. Solving this equation for IC₅₀ at the [In] when y = y₀/2 yields IC₅₀. The IC₅₀ was calculated based on a

nonlinear least-square regression fit using a commercial software package (DeltaGraph 4.0).

Using this assay, the IC_{50} of various compounds were determined. The IC_{50} for the various compounds was determined against deformylase enzyme containing nickel or zinc as the metal ion. The compound tested had an IC_{50} of less than 2 μM against deformylase enzyme containing nickel as the metal ion and less than 9 μM against deformylase enzyme containing zinc as the metal ion

Example 2

Assay for testing antimicrobial activity

Minimum inhibitory concentrations (MICs) were determined using the microdilution method in 96-well format plates. Compounds were suspended in DMSO at 5 or 10 mg/ml and stored at 4°C until used. They were diluted in Mueller-Hinton Broth (MHB) or Trypticase Soy Broth (TSB) and used for MIC determination. The range of concentrations tested was 64-0.0625 Tg/ml final concentration using a two-fold dilution system.

The inoculum was prepared from cells grown on Trypticase Soy Agar (TSA) and incubated overnight at 35 °C, 5 to 10 colonies were used to inoculate MHB or TSB broths, and the culture was incubated overnight at 35°C. The overnight culture was diluted 1:10, incubated for one hour at 35°C, diluted to the appropriate inoculum size and applied to the wells containing broth and test compound. Inoculum sizes were 2×10^4 CFU/ml.

Plates were incubated at 35°C for 48 hours and MIC were recorded after 18 hours of incubation for bacteria. MIC was defined as the lowest concentration of compound that does not produce visible growth after incubation.

Minimum inhibitory concentrations for various compounds against *H. influenza* and *S. aureus* was approximately 64 $\mu g/mL$ or less.

Minimum inhibitory concentrations for certain compounds of the Invention against *S. aureus*, *S. epidermidis*, *E. faecium*, *S. pneumoniae*, *H. influenzae*, *H. influenzae* acr, *M. catarrhalis*, *E. coli* and *E. coli* acr was approximately 64 $\mu g/mL$ or less.

Example 3

Demonstration of Selective Inhibition of PDF Compared to MMP-7 (Matrilysin)

As noted previously, inhibitors which are selective for peptidyl deformylase over matrix metalloproteinases are desirable in order to avoid side effects.

5 In order to test the compounds of the invention for possible inhibitory effects on matrix metalloproteinases, the following assay for MMP-7 (matrilysin) was used. MMP-7 (Matrilysin) Assay:

Matrilysin activity is assayed using a thio-peptide (Pro-Leu-Gly-S-Leu-Leu-Gly) as substrate. Upon enzyme hydrolysis, the thiolate is released as a product. The thiolate thus generated reacts with DTNB (dithionitrobenzene), giving rise to a yellow color which is monitored at 405 nm. The assay is carried out at room temperature; the assay buffer contains 50 mM Tricine, pH 7.5, 0.2 M NaCl, 10 mM CaCl₂, and 0.05% Brij, in a half-area 96-well microtiter plate. The reaction is initiated by adding a mixture of 200 TM DTNB and 100 TM thiopeptide in buffer. To determine IC₅₀ (the concentration needed to inhibit 50% of enzyme activity) values, MMP-7 was preincubated for 10 minutes with varying concentrations of compounds, and the hydrolysis initiated by the addition of reaction mixture containing thiopeptide and DTNB. The reaction rate was recorded as the absorbance increase in OD₄₀₅ over 30 minutes using a SpectraMax plate reader (Molecular Devices, Sunnyvale, CA). The inhibitor concentration [In] at which 50% of the enzyme activity is inhibited, IC₅₀, was calculated using the following formula:

$$y = y_0 / (1 + [In] / IC_{50})$$

where y_0 is the reaction velocity in the absence of inhibitor. Solving this equation for IC₅₀ at the [In] when $y = y_0/2$ yields IC₅₀.

25 Using this assay, the IC₅₀ of various compounds were determined. The compounds of the Invention tested were at least approximately 800 times more select for PDF than MMP-7. Similar selectivity of the compounds for peptidyl deformylase over MMP-1, MMP-2, MMP-3, MMP-9, MMP-13, MT-MMP-1, and tissue necrosis factor converting enzyme was observed. Similar selectivity was also observed over
30 other metalloproteinases such as angiotensin converting enzyme.

Example 4

Discontinuous PDF Assay

The gene for PDF was cloned from *S. aureus* and *E. coli* by PCR amplification. The PDF proteins were overexpressed in *E. coli*. The native Fe²⁺-containing PDF or its more stable surrogate Ni²⁺-containing PDF were prepared according to Wagner et al. (1998) *Biochemical & Biophysical Research Communications* **246**:342-6. Both enzymes have similar activity as reported in the literature. Discontinuous assay is carried out in a buffer of 10 mM NaCl and 50 mM HEPES, pH 7.2. Typically, 2 nM of PDF was incubated with inhibitor for 30 minutes prior to the addition of 4 mM fMAS substrate. The deformylation proceeded at room temperature for 30 minute. The enzyme activity is directly proportional to the amount of formate released, which can be quantified by monitoring the absorbance increase at 340 nm after the addition of 1 mM of NAD⁺ and 0.5 U/ml of formate dehydrogenase.

Example 5

Mouse septicemia model for determining in vivo efficacy

CD1 female out-bred mice (Charles River Laboratories) weighing 18-22 grams each were injected intraperitoneally with 0.5 ml of a suspension containing 5x10⁷ cfu of *S. aureus* (Smith strain) in 7% hog gastric mucosa (mucin). The mice were treated, either subcutaneously (SC), intravenously (IV) or orally (PO), 1hr and 5hr after infection. Six groups of six mice each were given different dosage levels representing two-fold dilutions of each compound (range of 100mg/kg – 0.1 mg/kg). Vancomycin was used as the control antibiotic and was administered SC. Compounds were formulated in PBS and untreated controls were dosed with vehicle alone.

Deaths in each group were monitored daily for 6 days and cumulative mortality was used to determine the 50% protective doses (PD₅₀), which were calculated using the method of Reed and Muench.

The foregoing invention has been described in some detail by way of illustration and example, for purposes of clarity and understanding. It will be obvious to one of skill in the art that changes and modifications may be practiced within the scope of the appended claims. Therefore, it is to be understood that the

above description is intended to be illustrative and not restrictive. The scope of the invention should, therefore, be determined not with reference to the above description, but should instead be determined with reference to the following appended claims, along with the full scope of equivalents to which such claims are
5 entitled.

All patents, patent applications and publications cited in this application are hereby incorporated by reference in their entirety for all purposes to the same extent as if each individual patent, patent application or publication were so individually denoted.

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